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WATER QUALITY OF THE MISSOURI RIVER (GAVINS POINT DAM TO HERMANN, MISSOURI). OCTOBER-NOVEMBER, 1968 AND JANUARY-FEBRUARY, 1969, SURVEYS

Richard K. Ballentine, et al

National Field Investigations Center
Cincinnati, Ohio

June 1970

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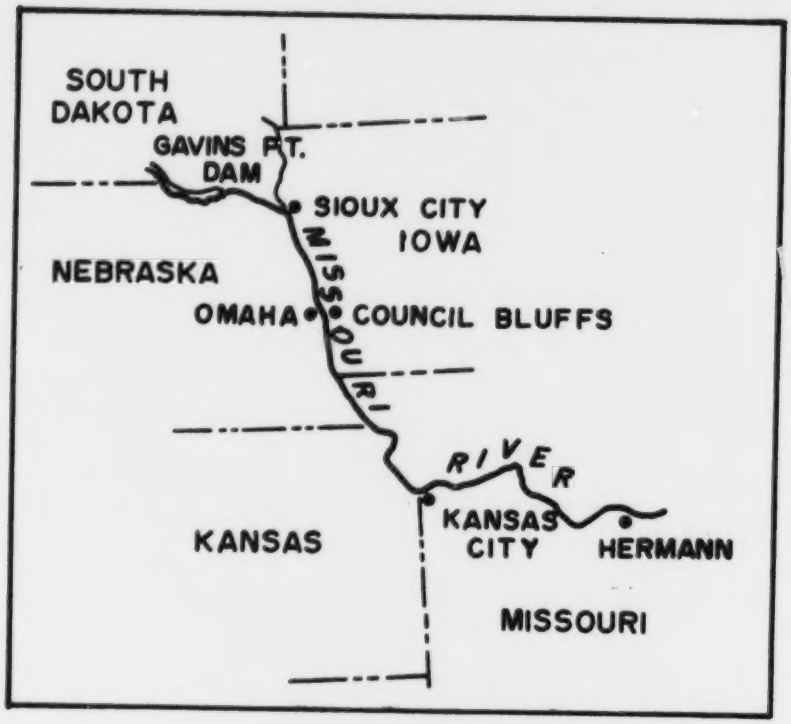
SURVEYS



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By Richard K. Ballentine, James E. Arden, Loys P. Parrish, Delbert B. Hicks, & Stephen L. Bugbee

FWPCA National Field Investigations Center
Cincinnati, Ohio June 1970

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(Gavins Point Dam to Hermann, Missouri)

OCTOBER-NOVEMBER 1968
AND
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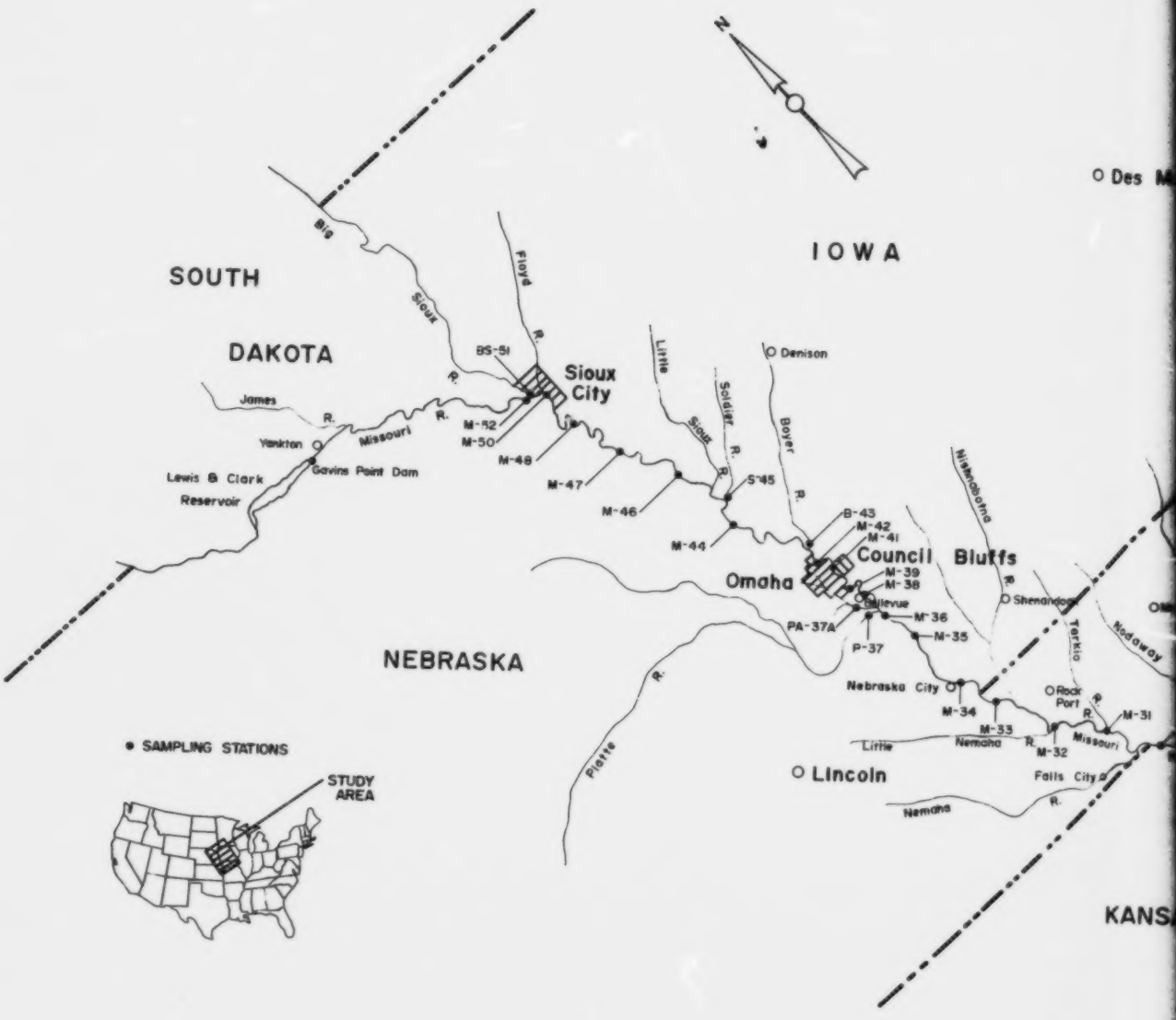
INTRODUCTION

This report is based on field surveys conducted by personnel from the National Field Investigations Center of the Federal Water Pollution Control Administration(FWPCA),* Cincinnati, Ohio in cooperation with the Missouri Basin Region, FWPCA, Kansas City, Missouri.

The purpose of the surveys was to determine Missouri River water quality along the 700-mile reach from Gavins Point Dam near Yankton, South Dakota, to Hermann, Missouri (Figure 1) which includes parts of the borders of South Dakota, Nebraska, Iowa, Missouri, and Kansas.

* throughout this report reference is made to the Federal Water Pollution Control Administration (FWPCA) which is now the Federal Water Quality Administration (FWQA).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Lincoln
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• SAMPLING STATIONS
STUDY AREA

FIGURE 1
LOCATION MAP
MISSOURI RIVER

1-A

SUMMARY

1. The subject of this report is the water quality in the 700-mile reach of the Missouri River from Gavins Point Dam near Yankton, South Dakota, to Hermann, Missouri. Major metropolitan areas include: Sioux City, Iowa; Omaha, Nebraska-Council Bluffs, Iowa; St. Joseph, Missouri; and Kansas City, Missouri.

2. Two chemical and bacteriological surveys were conducted. The first was from October 7 to November 8, 1968; the second from January 20 to February 2, 1969. An aquatic biological survey was conducted from October 7 to October 16, 1969.

3. Forty-five physical, chemical, biochemical, and bacteriological examinations were made on samples from 56 locations for the autumn (October-November, 1968) survey and 31 sampling locations for the winter (January-February, 1969) survey.

4. Three hydrologic conditions were encountered during the two surveys:

   a. "Normal" weather and navigational flows for the first eight sampling days of the first autumn survey between Gavins Point Dam and St. Joseph, Missouri (average flow 36,600 cfs), and for the second autumn survey between St. Joseph and Hermann, Missouri (average flow 55,600 cfs).

   b. Two days of heavy rainfall in the basin which caused nearly double normal navigational flows between Omaha, Nebraska and St. Joseph, Missouri for the last

two days of the first autumn survey. The flow averaged 70,400 cfs at St. Joseph.

c. Winter weather and non-navigational flows combined with river stages affected by ice jams were encountered during the winter survey. Flow at St. Joseph averaged 20,800 cfs.

5. At all stations, coliform bacteria densities exceeded by several times the National Technical Advisory Committee Criteria for sources of public water supply and for recreation.

Specifically:

a. During the normal weather periods of the autumn survey, the highest geometric mean total and fecal coliform bacteria densities were 256,000 MPN/100 ml and 61,200 MPN/100 ml respectively, downstream from Omaha-Council Bluffs; and 189,000 MPN/100 ml and 15,000 MPN/100 ml respectively, downstream from Kansas City, Missouri.

b. The coliform densities increased greatly during the autumn 2-day, rain-affected period. Both total and fecal coliform bacteria exceeded 100,000 MPN/100 ml at 19 of 21 river stations sampled with the highest 2-day densities of 1,440,000 MPN/100 ml and 1,120,000 MPN/100 ml respectively, occurring downstream from Nebraska City, Nebraska.

c. The winter survey bacterial densities were generally lower than those of the autumn survey. The highest geometric mean densities occurred downstream from the major metropolitan areas. Total coliform, fecal coliform, and fecal streptococci bacterial densities were 53,800 MPN/100 ml, 14,200 MPN/100 ml, and 61,100 respectively, downstream from Omaha-Council Bluffs, and 128,000 MPN/100 ml, 23,900 MPN/100 ml, and 26,600 MF/100 ml respectively downstream from Kansas City, Missouri.

6. Dissolved oxygen (D.O.) concentrations were greater than 8.3 mg/l during the autumn survey in the Gavins Point Dam to St. Joseph reach and were greater than 9 mg/l in the St. Joseph to Hermann, Missouri reach. Concentrations during the winter survey exceeded 9.0 mg/l in the total 700-mile reach. The lowest dissolved oxygen concentrations occurred during the 2-day, rain-affected period when the lowest average was 5.2 mg/l near St. Joseph.

7. A lead concentration of 0.085 mg/l for the average of two 5-day composite samples and cyanide concentrations of 6 µg/l downstream from Sioux City indicated potential toxicity in the Missouri River.

8. The total dissolved solids concentrations exceeded the recommended limit of 500 mg/l contained in the Public Health Service Drinking Water Standard at six of twenty stations during the first autumn survey upstream from St. Joseph. During the winter survey, twelve of twenty stations exceeded this criterion in the Gavins Point Dam to Hermann reach.

9. Radionuclide concentrations were much less than NTAC permissible criteria in the main stem of the Missouri River and in tributary streams. Concentrations were indicative of natural background levels for uranium, radium-226, and thorium-232. When calculated as gross alpha, the total concentrations, were 2.5 pc/l. Strontium-90 concentrations averaged about 1.8 pc/l during the autumn surveys.

10. A study of bottom-associated animal populations in 638 miles of the Missouri River downstream from Sioux City, Iowa, indicated at least 117 miles were severely degraded by organic pollution and an additional 99 miles were moderately degraded by pollution. Specifically:

    a. From Sioux City, Iowa to Omaha, Nebraska, and Council Bluffs, Iowa, stream bed animals reflected unpolluted conditions with the exception of localized degradation in the Sioux City area.

    b. Severe degradation of the bottom-associated organisms occurred for 54 miles downstream from the Omaha and Council Bluffs area. Objectionable floating solids (grease and chunks of animal fat) were evident from the Omaha and Council Bluffs area downstream past the St. Joseph, Missouri water supply intake a distance of approximately 166 miles.

c. Wastes from the Kansas City area and the Blue and Kansas Rivers produced adverse conditions for aquatic life for 66 river miles downstream as indicated by the absence of pollution-sensitive (clean water) bottom organisms.

d. Increasing numbers of pollution-sensitive bottom organisms occurred in farther downstream reaches which indicated recovery from severe pollution.

11. Biological studies indicated degraded water in tributaries to the Missouri River including the Big Sioux, Floyd, Soldier, Boyer, Kansas and Blue rivers.

12. Suspended algae in the Missouri River increased in numbers from 1,000 cells/ml to 6,000 cells/ml downstream from Omaha, Nebraska - Council Bluffs, Iowa.

METHOD OF STUDY

SAMPLE STATIONS

The autumn survey was designed to give more extensive river coverage when the river was readily accessible because of sustained navigational flows and sampling could be accomplished from boats. The winter survey was designed to reexamine water quality near urban areas with less extensive coverage at intervening, less accessible areas. Because of reduced flows and ice in the river, samples during this survey were collected from the stream banks at locations accessible by automobile.

Fifty-six sample stations were selected in the Gavins Point Dam to Hermann, Missouri river reach for the autumn survey (Appendix A). Twenty-nine sample stations were located in the upper reach from Gavins Point Dam to St. Joseph, Missouri and were sampled from October 7 to October 18, 1968 (first autumn survey period). Twenty-one of these stations were located on the main stem of the Missouri River, five stations were on tributary streams and three stations were waste sources.

In the lower reach from St. Joseph to Hermann, twenty-eight stations were sampled in the period of October 28 to November 8, 1968 (second autumn survey period). Twenty-one of these stations were on the main stem, five were tributary streams, and two were waste sources. One main stem station (M-27) of the upstream section was repeated.

Thirty-one sampling stations were established on the 700-mile reach during the period January 20 to February 2, 1969 (winter survey period). Twenty-four of these were on the main stem, two were on tributary streams and five were waste sources.

Stations sampled during the winter survey were located as closely as possible to the October 1968 locations. Where locations were not identical, a letter symbol was added to the station number in the summary tables to distinguish this difference (Appendix A).

ANALYSES

Many analyses were necessary to determine the water quality in the Missouri River. In addition to the biological examinations, 45 chemical, biochemical, and bacteriological examinations were included in the analysis series. Not all analyses were performed on daily discrete samples from each station. At selected stations composites from five daily samples were made and preserved for analysis of other constituents. Sample compositing was used to keep the required number of analyses within manageable limits. The sampling interval for each analysis is shown in Table No. 1; results of analyses are summarized in Appendix B.

Biological features studied were bottom-inhabiting invertebrate organisms and suspended algae (phytoplankton). Bottom sampling was at approximately 20 river mile intervals except in areas affected by waste discharges where additional stations were established. Forty stations on the Missouri River and one station on each of the major tributaries were sampled. Stations are designated with the same number as the closest chemical and bacteriological station where possible or as Corps of Engineer river miles measured upstream from the Missouri River confluence with the Mississippi River (Appendix A).

ANALYTICAL METHODS

All chemical analytical methods conformed to "FWPCA Official Interim Methods for Chemical Analysis of Surface Waters."* Except for modifications required for automated chemistry, methods contained in this volume are essentially the same as those contained in the 12th Edition of "Standard Methods for the Examination of Water and Wastewater."** Most of the heavy metal analyses were performed by atomic absorption spectroscopy.

Bacterial examinations were performed in accordance with "Standard Methods." In this report, the term "total coliform bacteria" refers to bacteria identified as the "Coliform Group" in Standard Methods.

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* "FWPCA Official Interim Methods for Chemical Analysis of Surface Waters," Federal Water Pollution Control Administration, September, 1968.

** "Standard Methods for the Examination of Water and Wastewater," 12th Edition, APHA, AWWA, WPCF, 1965.

TABLE 1

Frequency of Chemical Analyses
MISSOURI RIVER
(Gavins Point Dam to Hermann, Missouri)
OCT.-NOV., 1968 & JAN.-FEB., 1969 SURVEYS

CONSTITUENT OR ANALYSIS	DAILY	5-day Composite Sample	5-day Composite of Filtrate	3th Times per Survey Period	1 Time per Survey Period
ALL STATIONS					
Temperature	X				
Dissolved Oxygen (D.O.)	X(1)				
5- and 5-day Biochemical Oxygen Demand (B.O.D.)	X				
Total Alkalinity	X				
Specific Conductance	X				
Turbidity	X				
Chlorides	X(2)				
Sulfates	X(2)				
Total Dissolved Solids	X(2)				
Total Suspended Solids	X(2)				
Total Coliform Bacteria	X				
Fecal Coliform Bacteria	X				
Fecal Streptococci Bacteria	X(3)				
pH	X				
Magnesium		X			
Calcium		X			
Total Phosphorus		X			
Ammonia Nitrogen		X			
Nitrate Nitrogen		X			
Organic Nitrogen		X			
Total Organic Carbon		X			
SELECTED STATIONS					
20-day Biochemical Oxygen Demand (B.O.D.)				X(4)	
Sodium		X			
Potassium		X			
Fluoride		X			
Boron		X			
Arsenic			X		
Iron			X		
Barium			X		
Manganese			X		
Cadmium			X		
Chromium			X		
Copper			X		
Lead			X		
Nickel			X		
Zinc			X		
Phenol				X	
Cyanide				X	
Total Organic Chlorine					X
Chloroform Extract					X
Uranium (U^{235} & U^{238})		X			
Radium-226		X			
Thorium-232		X			
Total Alpha Thorium		X			
Strontium-90		X			

NOTE: (1) Dissolved oxygen was not performed on waste effluents but only on stream samples.
(2) Analyses were performed 3 times per week during the October-November, 1968 Survey; daily during the winter survey.
(3) Performed during the winter survey only.
(4) Performed twice during autumn survey; once during winter survey.

Bottom animal sampling was restricted to pile dikes and adjacent backwater areas because of river channelization and a shifting sand bottom. Pile dikes were examined to determine the representative kinds of benthic animals inhabiting a reach of river. Backwater areas were sampled for bottom organisms with either a Petersen or Ekman dredge. Dredgings were washed and strained through a U. S. Standard No. 30 sieve, and organisms remaining in the sieve were preserved for laboratory identification.

Suspended algal (phytoplankton) samples of one liter were collected at predetermined sampling stations and were preserved with five percent formalin for later identification.

MISSOURI RIVER AND TRIBUTARY FLOWS AND HYDROLOGY

Water released from Gavins Point Dam is the major controlling factor affecting Missouri River flows during dry weather periods. During periods of heavy rainfall the hydrology of tributary streams can greatly affect flows in the main stem of the Missouri River. Ice jams in the river during cold, winter weather can also interfere with normal stages and flow rates.

AUTUMN SURVEY

The Gavins Point Dam to St. Joseph, Missouri reach was sampled from October 7 to 18, 1968. For the period October 7 to 16, 1968, which included the first 8 days of sampling, river flows reflected normal weather conditions. An average of 31,300 cubic feet per second (cfs) was released from Gavins Point Dam (Table No. 2 and Appendix E.) Tributary inflows increased the flow to an average of 36,600 cfs at St. Joseph, Missouri, 360 miles downstream. Rainfall for this period was recorded at 0.46 inches at Omaha, Nebraska (Table No. 3).

Beginning late in the day on October 15, 1968, and continuing for the next two days, heavy rainfall occurred in the upstream reaches of the basin (Table No. 3). The average water released from Gavins Point Dam was reduced to 28,500 cfs for the period October 17 to 18, 1968. However, flows increased to 45,900 cfs (139 %) at Omaha; and to 70,400 cfs (192 %) at St. Joseph (Table No. 2). The ratio of rain-affected flows to dry weather flows generally increased in the downstream direction.

Tributary streams in this reach of the Missouri River exhibited even greater percentage flow increases between the normal weather period and the rain-affected period (Table No. 2). The greatest was the Soldier River which increased from 30 cfs to 1,050 cfs (3,500%). The October 7 to 18 survey period, therefore, reflects two distinctly different river conditions. Samples from the October 7 to 16 period reflect river conditions during "normal" autumn weather; samples from the October 17 to 18, 1968 period reflect river conditions warped by extremely heavy rains.

TABLE NO. 8

Summary of Average Daily Discharges[1/]

MISSOURI RIVER
Gavins Pt. Dam to St. Joseph, Missouri
October 7-18, 1968 and January 20-31, 1969 Surveys

STATION Name	River Mileage[2/]	1968 DISCHARGES cu.ft./sec. Oct. 7-16 Normal Fall	Oct. 17-18 Extremely Wet	Flow Ratio Wet/Normal	1969 DISCHARGES cu.ft./sec. Jan. 20-31 Non-Navigation	Flow Ratio 1969/1968 Normal
MISSOURI RIVER:						
Gavins Pt. Dam[3/], S. Dak.	811.0	31,300	28,500	0.91	16,900	0.54
Sioux City, Iowa	732.3	32,400	34,000	1.05	16,800	0.52
Omaha, Nebraska	615.9	33,100	45,900	1.39	15,000	0.45
Nebraska City, Nebraska	562.6	35,600	57,300	1.61	18,300	0.51
Rulo, Nebraska	498.0	36,300	70,600	1.94	19,200	0.53
St. Joseph, Missouri	448.2	36,600	70,400	1.92	20,800	0.57
TRIBUTARIES:						
Big Sioux River at Akron, Iowa	734.0	170	700	4.15	113	0.66
Soldier River at Pisgah, Iowa	664.0	30	1,050[4/]	35.00	35	1.17
Boyer River at Logan, Iowa	635.1	310	1,720	5.55	112	0.36
Platte River near South Bend, Nebr.	594.8	3,450	17,100	4.96	3,350[3/]	0.97
WASTE SOURCES:[5/]						
Sioux City, Iowa - STP	729.0	25.1 (16.2 mgd)		-	22.6 (14.6 mgd)	-
Council Bluffs, Iowa - STP	614.0	7.7 (5.0 mgd)[6/]		-	8.0 (5.2 mgd)	-
Omaha, Nebraska - Missouri R. STP	611.5	0[7/]		-	24.8 (16 mgd)	-
Monroe St. Sewer Omaha, Nebraska	611.5	53.1(34.3 mgd)	87.0 (56.2 mgd)[4/]	1.64	-	-

9.4

9-B

TABLE NO. 2
(contd)

Summary of Average Daily Discharges[1/]
(contd)
MISSOURI RIVER
St. Joseph to Hermann, Missouri
October 27-November 8, and January 20-February 2 Surveys

STATION Name	River Mileage[2/]	1968 DISCHARGES cu.ft./sec. Oct. 28-Nov. 8 Normal Fall	1969 DISCHARGES cu.ft./sec. Jan. 20-Feb. 2 Non-Navigation	Flow Ratio 1969/1968 Normal
MISSOURI RIVER:				
St. Joseph, Missouri	448.2	38,800	20,600	0.53
Kansas City, Missouri	366.1	46,300	28,100	0.61
Waverly, Missouri	293.4	45,500	29,300	0.64
Boonville, Missouri	196.6	48,500	46,700[8/]	0.96
Hermann, Missouri	97.9	55,600	92,700[8/]	1.67
TRIBUTARIES:				
Kansas River at Bonner Springs, Kansas	367.4	6,500	14,000	2.15
Grand River near Sumner, Missouri	250.0	167	5,500[8/]	33.10
Chariton River near Price Hill, Missouri	238.8	54	1,770[8/]	32.80
Osage River near St. Thomas, Missouri	130.0	5,380	21,000[8/]	3.90
Gasconade River near Jerome, Missouri [6/]	104.4	2,170	9,000[8/]	4.15
WASTE SOURCES:[5/]				
Kansas City, Kansas STP	367.20	12.1(7.81 mgd)	-	-
Kansas City, Missouri WEST SIDE STP	367.19	-	26.8 (17.3 mgd)	-
BLUE RIVER STP	356.9	65.9(42.6 mgd)	91.3 (59 mgd)[9/]	1.39

1/ Average flows based on provisional U. S. Geological Survey data except for waste sources, Gavins Point Dam releases, and Platte River in January, 1969.
2/ River Mileage refers to location of Missouri River USGS gage or to point where tributary or waste source enters Missouri River.
3/ Average flows based on U. S. Army Corps. of Engineers data.
4/ Average includes daily flow on 10/16/68.
5/ Waste source flows are averages for sample days only and may be precipitation-affected.
6/ Flow estimated from information provided by plant personnel.
7/ No flow due to shutdown for system repairs. All sewage was by-passed raw from many outfalls along the Omaha waterfront.
8/ Discharges are for period from January 20-31, 1969.
9/ Average includes a daily raw sewage bypass of 43 mgd.

TABLE NO. 3

Weather Summary
For the Survey Periods
MISSOURI RIVER

LOCATION	Inclusive Periods Normal	Inclusive Periods Wet	Rainfall Inches Normal	Rainfall Inches Wet	Air Temp. °F Avg. Max.	Air Temp. °F Avg. Min.
	Oct.	Oct.				
Sioux City, Ia.	7-14	15-18	0.48	4.12	66.2	48.8
Omaha, Nebraska	7-15	16-18	0.46	3.61	69.8	51.7
Auburn, Nebraska	7-15	16-18	0.08	3.90	70.8	52.2
St. Joseph, Mo.	7-15	16-18	1.29	1.32	74.7	54.5
St. Joseph, Mo.	Oct. 28-Nov. 8		0.69		60.3	36.2
Kansas City, Mo.	"		0.57		58.3	39.8
Jefferson City, Mo.	"		1.67		61.7	36.3
Hermann, Mo.	"		1.73		-	-
Sioux City, Ia.	Jan. 20-31		0.61		18.1	2.6
Omaha, Nebraska	"		0.46		22.6	6.0
Auburn, Nebraska	"		0.50		26.5	10.8
St. Joseph, Mo.	Jan. 23-Feb. 2		0.55		32.7	15.3
Kansas City, Mo.	"		0.53		33.2	17.6
Jefferson City, Mo.	Jan. 20-31		3.69		37.3	21.2
Hermann, Mo.	"		2.94		-	-

The St. Joseph, Missouri to Hermann, Missouri reach was sampled during the period October 28 to November 8, 1968. River flow rates had subsided from the peak of the previous period. Flows averaged 38,800 cfs at St. Joseph and 55,600 cfs 350 miles downstream at Hermann. Approximately 84 percent of the flow increase in this reach during the survey period was contributed by three tributaries: the Kansas River (6,500 cfs), Osage River (5,380 cfs) and Gasconade River (2,170 cfs).

Precipitation during this period was recorded as 0.57 inches at Kansas City, Missouri (Table No. 3).

WINTER SURVEY

Flows during the January to February, 1969 survey were affected by ice jams in the river upstream from Kansas City and by rain downstream. For much of the survey period, river stages were higher than normal summer navigational levels in the reaches upstream from St. Joseph. Flow rates were affected by the damming effect of the ice jams downstream. At Omaha, flows averaged about 1,800 cfs less than that released from Gavins Point Dam (Table No. 2). The flow at St. Joseph averaged 20,800 cfs. Upstream and immediately downstream from the ice jams flows were reduced during the second week of the survey. The flow at Kansas City was composed of 64.5% Missouri River water the first week but only 30.0% the second week (Table No. 2). Approximately two-thirds of the flow at Kansas City was composed of Kansas River water during the second week.

The flow increased slightly to 29,300 cfs at Waverly, Missouri; to 46,700 cfs at Boonville, Missouri 97 miles farther downstream; and to 92,700 cfs at Hermann, another 100 miles downstream. These flows ranged from 53% of the October 28 to November 8 flows at Kansas City to 167% at Hermann. Tributary flows increased from 215% to 3,310% of the earlier period.

Precipitation during the winter survey was 0.46 inches at Omaha, 0.53 inches at Kansas City and 3.69 inches at Jefferson City. These data indicate the large amount of precipitation downstream from Kansas City.

Most of the precipitation was in the form of snow upstream from St. Joseph. Precipitation downstream occurred as a combination of snow, sleet, and rain.

WATER QUALITY

BACTERIAL POLLUTION

Total and fecal coliform bacteria enumeration analyses were performed during the two autumn survey periods of the Missouri River. Fecal streptococci bacteria were enumerated in addition to the coliform analyses during the winter survey.

The report of the National Technical Advisory Committee to the Secretary of the Interior (NTAC Report)** has numeric bacterial criteria for natural waters used for public water supplies and for recreation. The permissible criterion for a source of public water supply is a "...monthly arithmetic average based upon an adequate number of samples..."** of 10,000/100 ml total coliform bacteria and 2,000/100 ml fecal coliform bacteria. The criteria for recreation is divided into three classifications. These classifications and numerical limits are: General recreational use of surface waters,"... average not to exceed 2,000 fecal coliforms per 100 ml..."**; waters designated for recreation uses other than primary contact recreation," ... should not exceed a log mean*** of 1,000/100 ml..."** fecal coliform bacteria; and primary contact recreation,"...shall not exceed a log mean of 200/100 ml..."**fecal coliform bacteria.

Geometric mean*** bacterial densities and the 80% confidence limits for the autumn surveys versus time-of-water travel and river mile are presented graphically in Figures 2 and 3. The time-of-water travel analysis for the autumn survey is included as Appendix D. The winter survey bacterial densities versus river mile are presented in Figure 4. Ice jams affected river stage-discharge relationships making accurate time-of-water travel calculations difficult upstream from Kansas City, Missouri. An unstable hydrograph downstream from Kansas City affected time-of-water travel such that only an average of a wide interval could be calculated. Thus, time-of-water travel is not meaningful for the winter survey period.

** Anon. 1968. Water Quality Criteria. Report of the National Technical Advisory Committee for the Secretary of the Interior, Federal Water Pollution Control Administration, Washington, D.C.

*** Log mean and geometric mean are equivalent terms, i.e., the antilogarithm of the average of the logarithms of a set of numbers.

Gavins Point Dam - St. Joseph, Missouri

Water released from Gavins Point Dam contained low densities of coliform bacteria during the upstream autumn sampling period. Total and fecal coliform bacteria had been increased from mean* densities of 250 MPN/100 ml and less than 120 MPN/100 ml, respectively to 1,380 MPN/100 ml and 220 MPN/100 ml respectively, at Station M-52 (R.M. 736.0) upstream from Sioux City.

Waste from the Sioux City area increased total and fecal coliform densities to 62,800 MPN/100 ml and 14,300 MPN/100 ml respectively, at Station M-48, located 4.5 hours time-of-water travel downstream from the Sioux City sewage treatment plant (STP) discharge. A major cause of this increase in bacterial densities was the unchlorinated discharge from the Sioux City primary sewage treatment plant (Table 7). Another major waste source is the Iowa Beef Packers plant at Dakota City, Nebraska. This plant, providing minimal waste treatment, was not sampled during these surveys.

Coliform densities decreased downstream from the Sioux City area. The trend lines in Figure 2 illustrate the indicated decrease. At the Omaha Metropolitan Utility District (M.U.D.) water intake (Station 42, R.M. 626.2), 34 hours time-of-water travel downstream from the Sioux City STP discharge, the mean total and fecal coliform bacteria densities were 52,300 MPN/100 ml and 8,320 MPN/100 ml, respectively. These densities were 5.2 times and 4.1 times respectively, the NTAC criteria for sources of supply for public drinking water.

Wastes from the Omaha, Nebraska-Council Bluffs, Iowa area increased the mean bacterial densities to 256,400 MPN/100 ml and 61,200 MPN/100 ml total and fecal coliform bacteria respectively, at Station M-39 (R.M. 610.5),** 0.2 hours time-of-water travel downstream from the Monroe Street sewer outfall. The major causes of this increase were the wastes from Omaha including the 34.3 million gallons per day (MGD) of untreated packing house wastes plus an estimated 16 MGD of raw sewage bypassed because of a pumping station outage; and 5 MGD of unchlorinated effluent from the Council Bluffs, Iowa primary sewage treatment plant.

Downstream from Omaha-Council Bluffs coliform bacteria densities decreased. At the St. Joseph, Missouri Water Company intake, mean total and fecal coliform densities had decreased to 57,700 MPN/100 ml and 6,500 MPN/100 ml, respectively. These levels are respectively 5.8 times and 3.2 times the drinking water criteria in the NTAC report.

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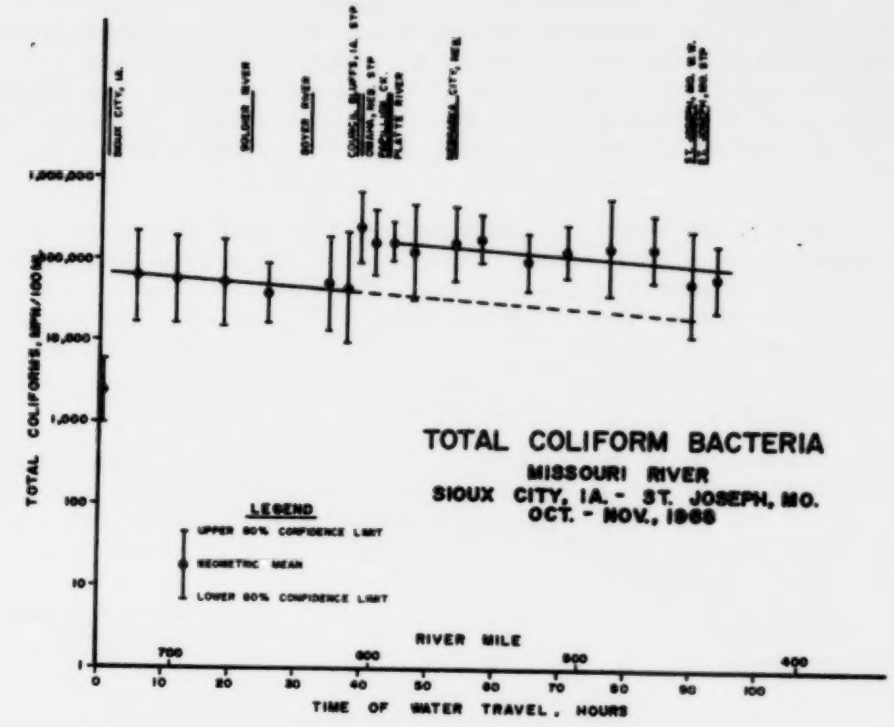
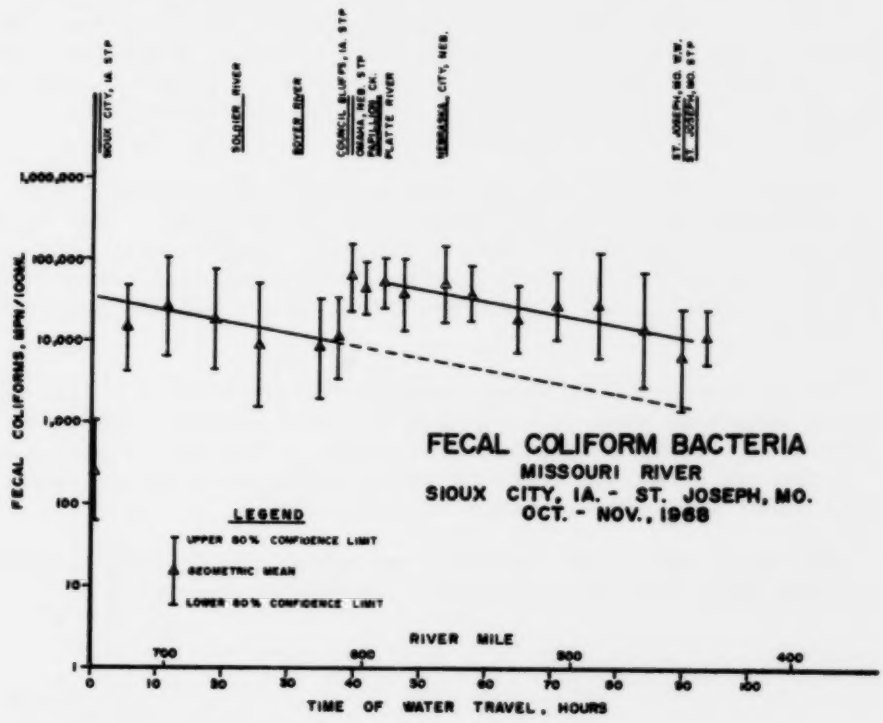
*In discussion of bacteria densities, "mean" refers to geometric mean throughout this report.

**Laboratory composited sample made from quarter point samples (3 samples per station cross-section).

FIGURE 2



TOTAL COLIFORM BACTERIA
MISSOURI RIVER
SIOUX CITY, IA. - ST. JOSEPH, MO.
OCT. - NOV., 1968



FECAL COLIFORM BACTERIA
MISSOURI RIVER
SIOUX CITY, IA. - ST. JOSEPH, MO.
OCT. - NOV., 1968

Graphical extrapolation of the trend lines in Figure 2 indicates that of the bacterial contamination at the St. Joseph Water Company intake about 24% of the total coliform bacteria and 15% of the fecal coliform bacteria were from sources upstream from Omaha-Council Bluffs (primarily from the Sioux City area). The remainder of the contamination was introduced from the Omaha-Council Bluffs area.

During the 2-day rain-affected period, coliform bacteria increased to very high densities throughout the entire reach. Nineteen of the 21 sampling stations had both total and fecal coliform bacterial densities that exceeded 100,000 MPN/100 ml. The highest densities were at Station M-34 (R.M. 559.7) downstream from Nebraska City, Nebraska where densities were 1,440,000 MPN/100 ml and 1,120,000 MPN/100 ml total and fecal coliform bacteria, respectively.

Comparison of the column in Table B-4 entitled "fecal coliform bacteria as a percent of total coliform bacteria" for the 8-day normal period and the 2-day wet period showed a much higher ratio at most stations during the wet period. This large increase in percent fecal coliform bacteria indicates that the coliform bacteria from land runoff were largely from fecal sources. Such areas as feedlots and pastures are heavily contaminated and yield large numbers of fecal coliform bacteria.

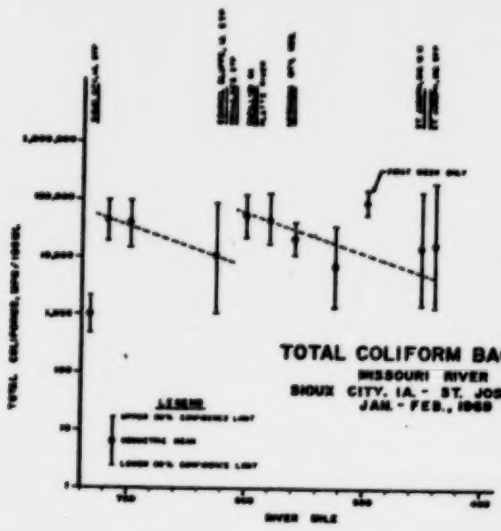
Coliform bacterial densities during the winter survey were substantially less than during the 8-day normal weather period in October 1968 even though stream flow was reduced by about 50% (Figure 3, Appendix Tables B-4 and B-6). The decrease in the winter densities within the Sioux City-Omaha reach was partially caused by the reduced densities in the waste flow from the Sioux City STP discharge (Table No. 7). Reductions in bacterial densities also occurred in portions of the wastes discharged in Omaha. Municipal wastes bypassed during the autumn study received treatment during the winter study.

Downstream from the Sioux City area at Station M-48A (R.M. 718.3) bacterial densities increased to 44,300 MPN/100 ml and 11,200 MPN/100 ml total and fecal coliform bacteria, respectively, and 16,500 MF/100 ml fecal streptococci bacteria. Both fecal coliform and fecal streptococci bacteria had higher densities downstream at Station M-47 (R.M. 699.5).

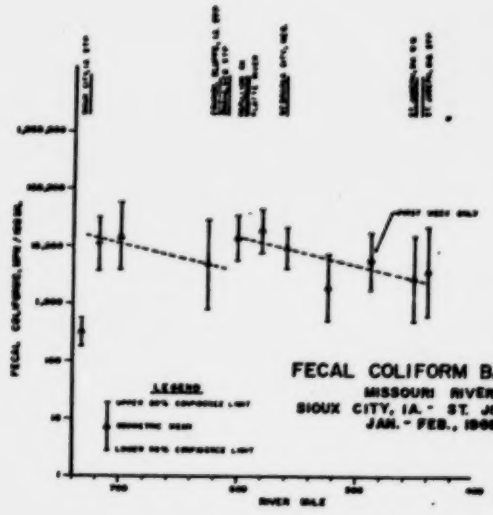
At the Omaha M.U.D. Water Intake (Station M-42, R.M. 626.2) bacterial densities were reduced from upstream levels. The total coliform densities were approximately equal to the NTAC report criteria for sources of public drinking water supplies; however, fecal coliform densities were 2.9 times the criteria.

Bacterial densities increased following the introduction of wastes from Omaha and Council Bluffs. Bacterial densities at

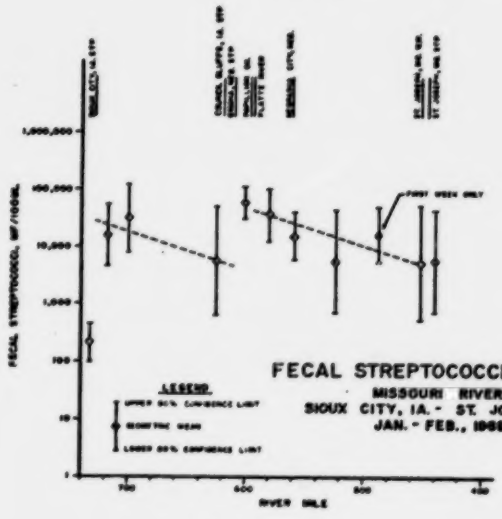
FIGURE 3



TOTAL COLIFORM BACTERIA
MISSOURI RIVER
SIOUX CITY, IA. - ST. JOSEPH, MO.
JAN. - FEB., 1969



FECAL COLIFORM BACTERIA
MISSOURI RIVER
SIOUX CITY, IA. - ST. JOSEPH, MO.
JAN. - FEB., 1969



FECAL STREPTOCOCCI BACTERIA
MISSOURI RIVER
SIOUX CITY, IA. - ST. JOSEPH, MO.
JAN. - FEB., 1969

Station M-38 (R.M. 601.3) increased to 53,800 MPN/100 ml and 14,200 MPN/100 ml total and fecal coliform bacteria respectively, and 61,100 MF/100 ml fecal streptococci bacteria. The mean fecal coliform density was larger downstream at Station M-35 (R.M. 580.9).

Bacterial densities decreased farther downstream. However, the effect of the increased time-of-water travel caused by the ice jams downstream exaggerated the apparent rate of decrease.

St. Joseph, Missouri-Hermann, Missouri

Station M-27 (R.M. 440.3), located about 2 hours time-of-travel downstream from the St. Joseph sewage treatment plant (STP) outfall, was sampled during both the upstream and downstream autumn surveys. Coliform densities were similar during each survey with means of 67,000 MPN/100 ml and 8,100 MPN/100 ml total and fecal coliforms respectively, during the latter St. Joseph-Hermann survey (Figure 4) and 65,300 MPN/100 ml and 11,800 MPN/100 ml respectively, during the upstream autumn survey.

In the reach between St. Joseph and Kansas City, wastes from the Kansas communities of Atchison and Leavenworth enter the Missouri River. The bacteriological effects of wastes from these communities are not readily discernible in Figure 4. This is the result of high residual densities from upstream sources, a large amount of variation in the data as indicated by the 80 % confidence limits, and the dilution afforded by river flows in excess of 38,800 cfs.

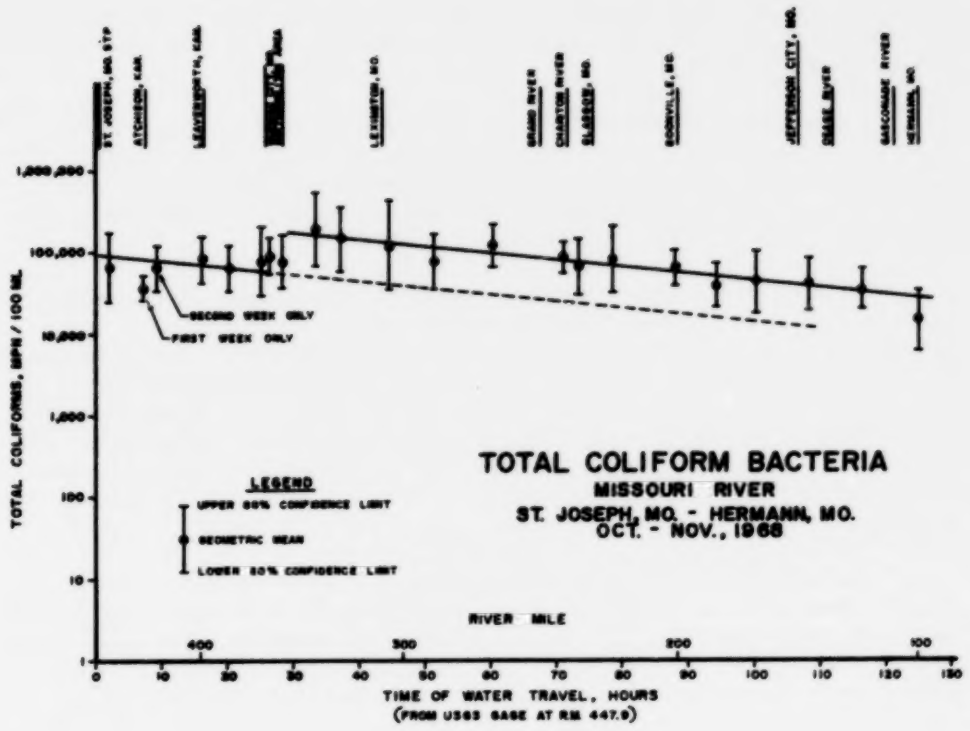
Densities upstream from the Kansas River at Station M-23 (R.M. 370.5) located at the Kansas City, Missouri Water Works Intake, were 77,000 MPN/100 ml and 6,500 MPN/100 ml total and fecal coliform bacteria, respectively. These levels are 7.7 times and 3.2 times respectively, criteria recommended by the NTAC report for sources of public water supplies.

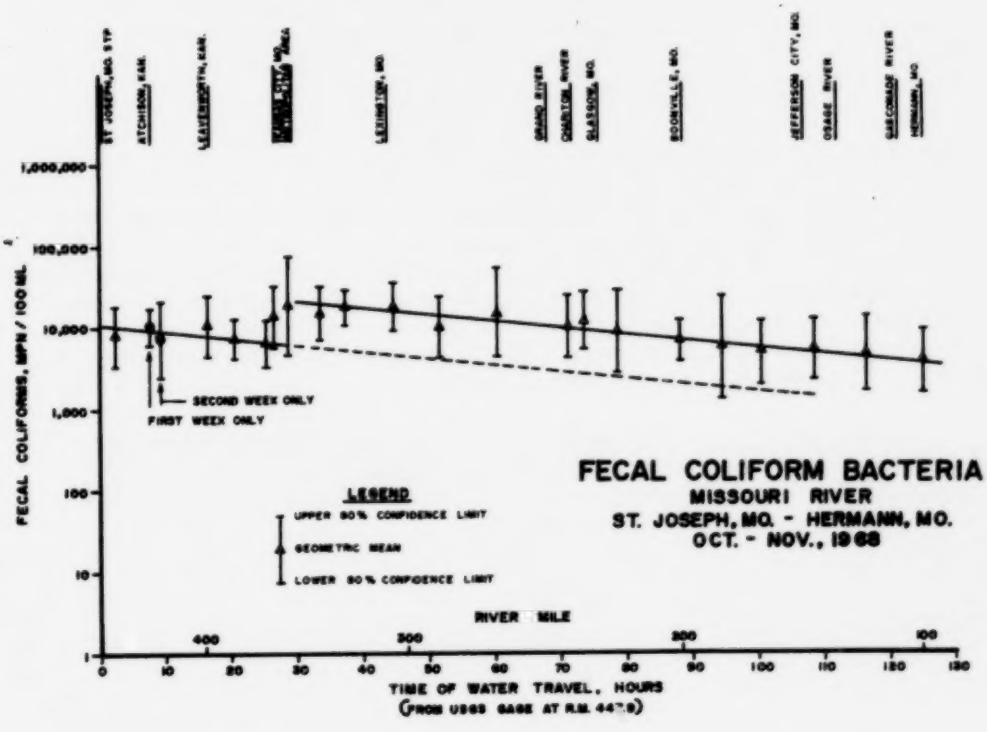
Bacterial densities in the Missouri River were increased by the inflow of: the Kansas River; the Kansas City, Kansas sewage treatment plant; the Kansas City, Missouri west side sewage treatment plant; and the Blue River which contained the Kansas City, Missouri, Blue River sewage treatment plant effluent (Appendix Table B-2). Densities were increased to 189,000 MPN/100 ml and 15,000 MPN/100 ml total and fecal coliform bacteria at Station M-18 (R.M. 345.4) 3.9 hours time-of-water travel downstream from the Blue River.

Coliform densities decreased downstream from the Kansas City area but were greater than recommended water use criteria. At Station M-16 (R.M. 313.2) located within 1 hour time-of-travel from the Lexington, Missouri water intake, total and fecal coliform densities were 11.9 times and 9.0 times the NTAC report criteria for a

14-A

FIGURE 4


ST. JOSEPH, MO. STP
ATCHISON, KAN.
LEAVENWORTH, KAN.
LEXINGTON, MO.
GRAND RIVER
CHARITON RIVER
GLASGOW, MO.
BOONVILLE, MO.
JEFFERSON CITY, MO.
OSAGE RIVER
GASCONADE RIVER
HERMANN, MO.
TOTAL COLIFORMS, MPN / 100 ML.
1,000,000
100,000
10,000
1,000
100
10
1
SECOND WEEK ONLY
FIRST WEEK ONLY
LEGEND
UPPER 80% CONFIDENCE LIMIT
GEOMETRIC MEAN
LOWER 80% CONFIDENCE LIMIT
TOTAL COLIFORM BACTERIA
MISSOURI RIVER
ST. JOSEPH, MO. - HERMANN, MO.
OCT. - NOV., 1968
RIVER MILE
400
300
200
100
0
10
20
30
40
50
60
70
80
90
100
110
120
130
TIME OF WATER TRAVEL, HOURS
(FROM USGS GAGE AT R.M. 447.9)


ST. JOSEPH, MO. STP
ATCHISON, KAN.
LEAVENWORTH, KAN.
LEXINGTON, MO.
GRAND RIVER
CHARITON RIVER
GLASGOW, MO.
BOONVILLE, MO.
JEFFERSON CITY, MO.
OSAGE RIVER
GASCONADE RIVER
HERMANN, MO.
FECAL COLIFORMS, MPN / 100 ML.
1,000,000
100,000
10,000
1,000
100
10
1
SECOND WEEK ONLY
FIRST WEEK ONLY
LEGEND
UPPER 80% CONFIDENCE LIMIT
GEOMETRIC MEAN
LOWER 80% CONFIDENCE LIMIT
FECAL COLIFORM BACTERIA
MISSOURI RIVER
ST. JOSEPH, MO. - HERMANN, MO.
OCT. - NOV., 1968
RIVER MILE
400
300
200
100
0
10
20
30
40
50
60
70
80
90
100
110
120
130
TIME OF WATER TRAVEL, HOURS
(FROM USGS GAGE AT R.M. 447.9)

source of public water supply. These same criteria were also exceeded at the water supply intakes for the Missouri communities of Glasgow (approximately 7 and 4.4 times the criteria respectively), Boonville (approximately 5.7 and 3.4 times the criteria respectively), and Jefferson City (approximately 4 and 2.4 times the criteria respectively).

Graphical extrapolation of the trend lines in Figures 4A and 4B indicate that about 34% of the total coliform bacteria and 30% of the fecal coliform bacteria at Jefferson City were from sources upstream from Kansas City. The remainder of the coliforms were principally from the Kansas City area.

During the winter survey, bacterial densities downstream from the St. Joseph area were affected by flow phenomena. Calculations indicate that only a fraction of the Missouri River water at St. Joseph reached Kansas City during this period (see Flow Section for discussion). The character of the river water changed downstream from the Kansas River as it furnished an average of one-half the flow of the Missouri River during the study period. Bacterial densities in the Kansas River were not determined during the winter survey.

Densities at Station M-17 downstream from Kansas City (R.M. 334.5) were 128,000 MPN/100 ml and 23,900 total and fecal coliform bacteria respectively, and 26,600 MF/100 ml fecal streptococci bacteria. Bacterial densities exhibited a decreasing trend in the downstream direction even though rains caused tributaries to flow at several times the November, 1968 rates (Figure 5).

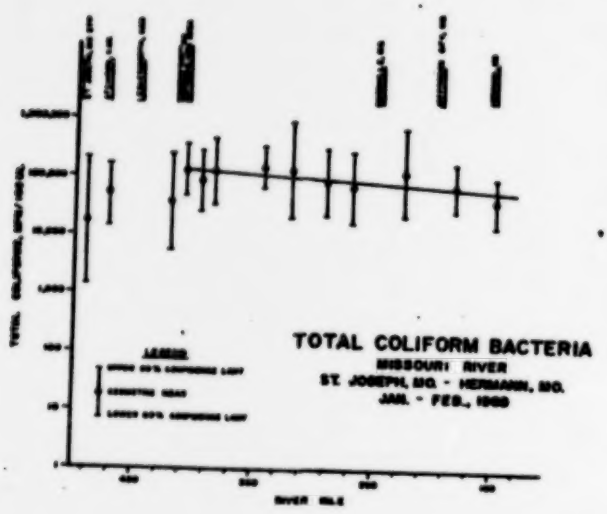
The NTAC report criteria for sources of public drinking water supplies of 10,000/100 ml total coliform bacteria and 2,000/100 ml fecal coliform bacteria was again exceeded at all water supply withdrawal points in this reach.

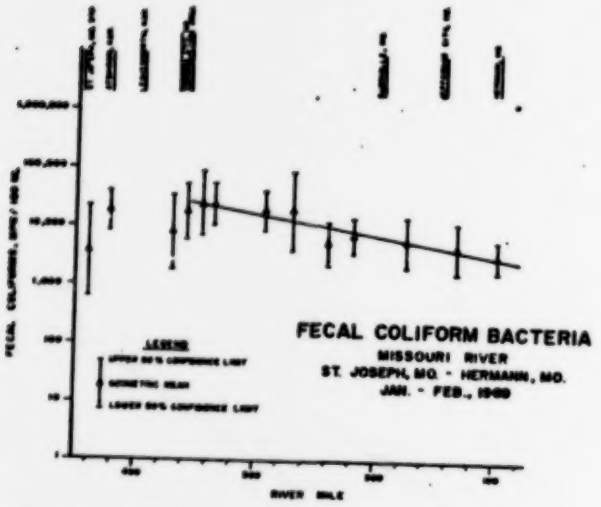
BIOCHEMICAL OXYGEN DEMAND (BOD)

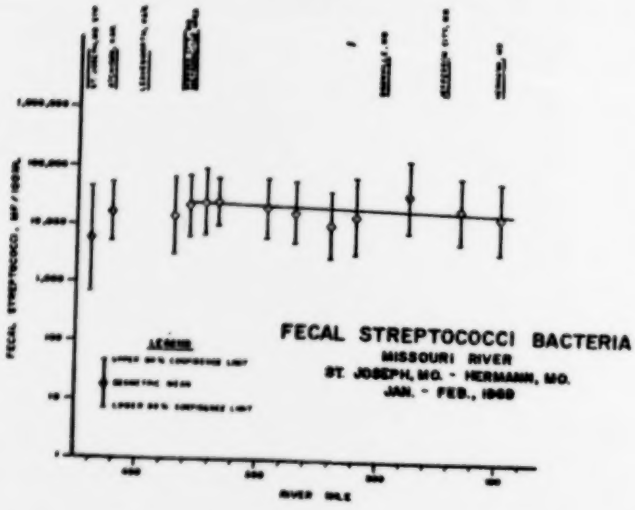
Wastes containing oxygen demanding organic materials, such as municipal sewage, remove dissolved oxygen from the aquatic environment in the process of the biochemical decomposition and stabilization of these materials. A principal function of waste treatment is the removal of such oxygen-demanding materials. A common measure of the strength of these materials is the 5-day, 20° C. biochemical oxygen demand (BOD_5).

In these surveys, 2-day and 5-day BOD analyses were performed. The use of both analyses permitted estimation of the reaction rates of BOD satisfaction. A detailed analysis of the BOD data is presented in Appendix C.

FIGURE 5


TOTAL COLIFORM BACTERIA
MISSOURI RIVER
ST. JOSEPH, MO. - HERMANN, MO.
JAN. - FEB., 1969


FECAL COLIFORM BACTERIA
MISSOURI RIVER
ST. JOSEPH, MO. - HERMANN, MO.
JAN. - FEB., 1969


FECAL STREPTOCOCCI BACTERIA
MISSOURI RIVER
ST. JOSEPH, MO. - HERMANN, MO.
JAN. - FEB., 1969

Gavins Point Dam-St. Joseph, Missouri

The BOD_5 for the 8-day normal weather period during the upstream autumn survey reflected the waste discharges from the major metropolitan areas (Figure6). From background concentrations upstream from Sioux City (< 1.0 mg/1) the BOD_5 was increased to 1.6 mg/1 at Station M-47 (R.M. 699.5) by wastes from that area. Waste discharges from the Omaha-Council Bluffs area increased the BOD_5 to 5.8 mg/1 at Station M-39 (R.M. 610.5). The concentration decreased irregularly downstream to the St. Joseph Water Company Intake.

The average BOD_5 concentrations for the 2-day, rain-affected period increased substantially throughout the entire survey reach. Increases ranged from 1.3 times (0.9 mg/1 to 1.2 mg/1) at Station M-52 (R.M. 736.0) to 2.2 times (3.4 mg/1 to 7.6 mg/1) at Station M-29 (R.M. 469.0). As was indicated by increases in the bacterial densities, much of this increase was from organic material transported by surface runoff from feedlots and pastures tributary to the river.

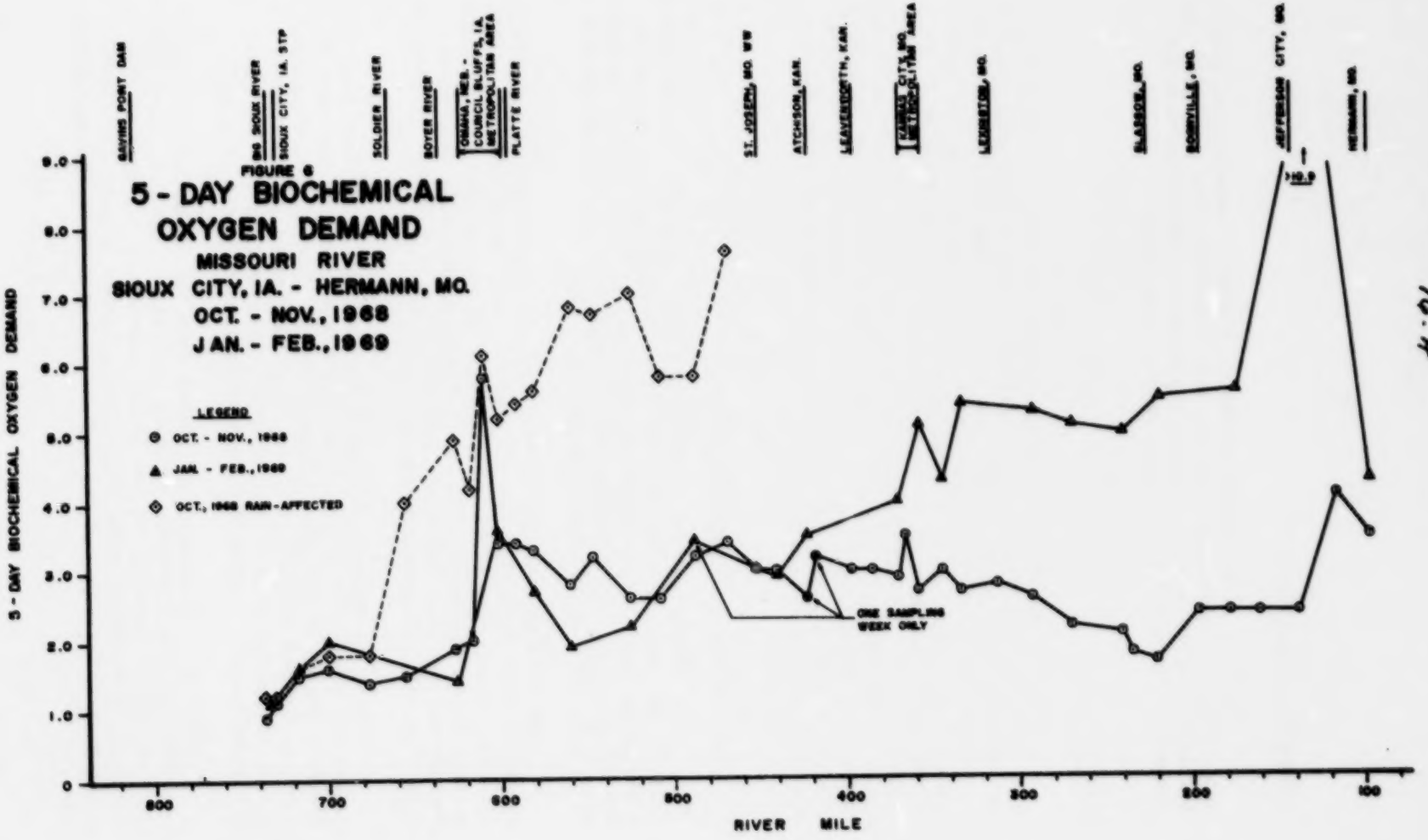
The winter survey data indicated concentration increases similar to the normal weather period of the autumn survey for the Sioux City and Omaha metropolitan areas. BOD_5 concentrations were reduced downstream from Omaha-Council Bluffs partially because of the increased time-of-water travel caused by the ice jams and resultant sedimentation of suspended organic material.

St. Joseph, Missouri-Hermann, Missouri

The average BOD_5's remained relatively constant between St. Joseph and Kansas City with averages of approximately 3 mg/1. Wastes from Kansas City increased the BOD_5 to 3.5 mg/1 at Station M-21 (R.M. 365.6). The concentration decreased downstream from Kansas City and reached the lowest average of 1.7 mg/1 at Station M-9 (R.M. 221.0). Downstream from this point the BOD_5 increased irregularly.

The average BOD_5 concentration trend between St. Joseph and Kansas City was affected by the hydraulic interferences of the ice jams during the winter survey. Downstream from the Kansas City area waste discharges increased the BOD_5 to 5.4 mg/1 at Station M-17 (R.M. 334.5). The concentration was slightly reduced to 5.0 mg/1 at Station M-12 (R.M. 241.2).

BOD_5 concentrations farther downstream were affected by the large amounts of rain and irregular main stem and tributary hydrographs.


BIG SIOUX RIVER
SIOUX CITY, IA. STP
SOLDIER RIVER
BOYER RIVER
OMAHA, NEB. - COUNCIL BLUFFS, IA. METROPOLITAN AREA
PLATTE RIVER
ST. JOSEPH, MO. STP
ATCHISON, KAN.
LEAVENWORTH, KAN.
KANSAS CITY, MO. - KANSAS CITY, KAN. METROPOLITAN AREA
LEXINGTON, MO.
BOONVILLE, MO.
JEFFERSON CITY, MO.
HERMANN, MO.
FIGURE 6
5 - DAY BIOCHEMICAL OXYGEN DEMAND
MISSOURI RIVER
SIOUX CITY, IA. - HERMANN, MO.
OCT. - NOV., 1968
JAN. - FEB., 1969
LEGEND
OCT. - NOV., 1968
JAN. - FEB., 1969
OCT., 1968 RAIN-AFFECTED
ONE SAMPLING WEEK ONLY
>10.0
5 - DAY BIOCHEMICAL OXYGEN DEMAND
RIVER MILE
0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
800
700
600
500
400
300
200
100

DISSOLVED OXYGEN (D.O.)

The D.O. of a flowing stream or a body of water is an important, necessary constituent to maintain desirable fish and other aquatic life, and to maintain pleasing aesthetic conditions by avoiding obnoxious odors associated with septic conditions.

D.O. Criteria

For sources of public water supply, the NTAC criterion for D.O. is a monthly mean equal to or greater than 4 mg/l with individual samples equal to or greater than 3 mg/l. The NTAC report states, "Criteria for dissolved oxygen are included, not because the substance is of appreciable significance in water treatment or in finished water, but because of its use as an indicator of pollution by organic wastes." NTAC criteria for fish and other aquatic life applicable to the Missouri River is stated, "For a diversified warm-water biota, including game fish, the D.O. concentration should be above 5 mg/l,...however, they may range between 5 and 4 mg/l for short periods during any 24-hour period,..."

Gavins Point Dam - St. Joseph, Missouri

D.O. concentrations averaged 8.3 mg/l or greater in the main stem of the Missouri River for the first 8 sampling days of the October 7-18, 1968 survey (Figure 7 and Appendix Table B-1). The highest average D.O. concentration was 9.5 mg/l and occurred at Station M-52 (R.M. 736) upstream from Sioux City, Iowa.

The rain-affected, 2-day average D.O. concentrations generally decreased from Sioux City to St. Joseph. D.O. concentrations varied inversely with river flows; as the ratio of wet weather flows to dry weather flows increased, D.O. concentrations generally decreased. Two-day average D.O. concentrations had a low of 5.2 mg/l at Station M-29 (R.M. 469.0) upstream from St. Joseph.

During the January-February, 1969 survey, D.O. concentrations showed the effects of an ice cover which was formed by blockage of floating ice by an ice jam upstream from St. Joseph. As additional floating ice was trapped, the ice cover was backed-up past Omaha during the second week of the survey. Upstream from the ice cover and Omaha-Council Bluffs, D.O. concentrations exceeded 12.5 mg/l.

With the introduction of wastes from the Omaha-Council Bluffs area and with the ice cover reducing reaeration, the D.O. concentrations decreased steadily to the lowest average of 9.1 mg/l at Station M-30 (R.M. 488.3) near White Cloud, Kansas (Figure 7). Downstream from St. Joseph and the ice cover, the D.O. concentration increased.

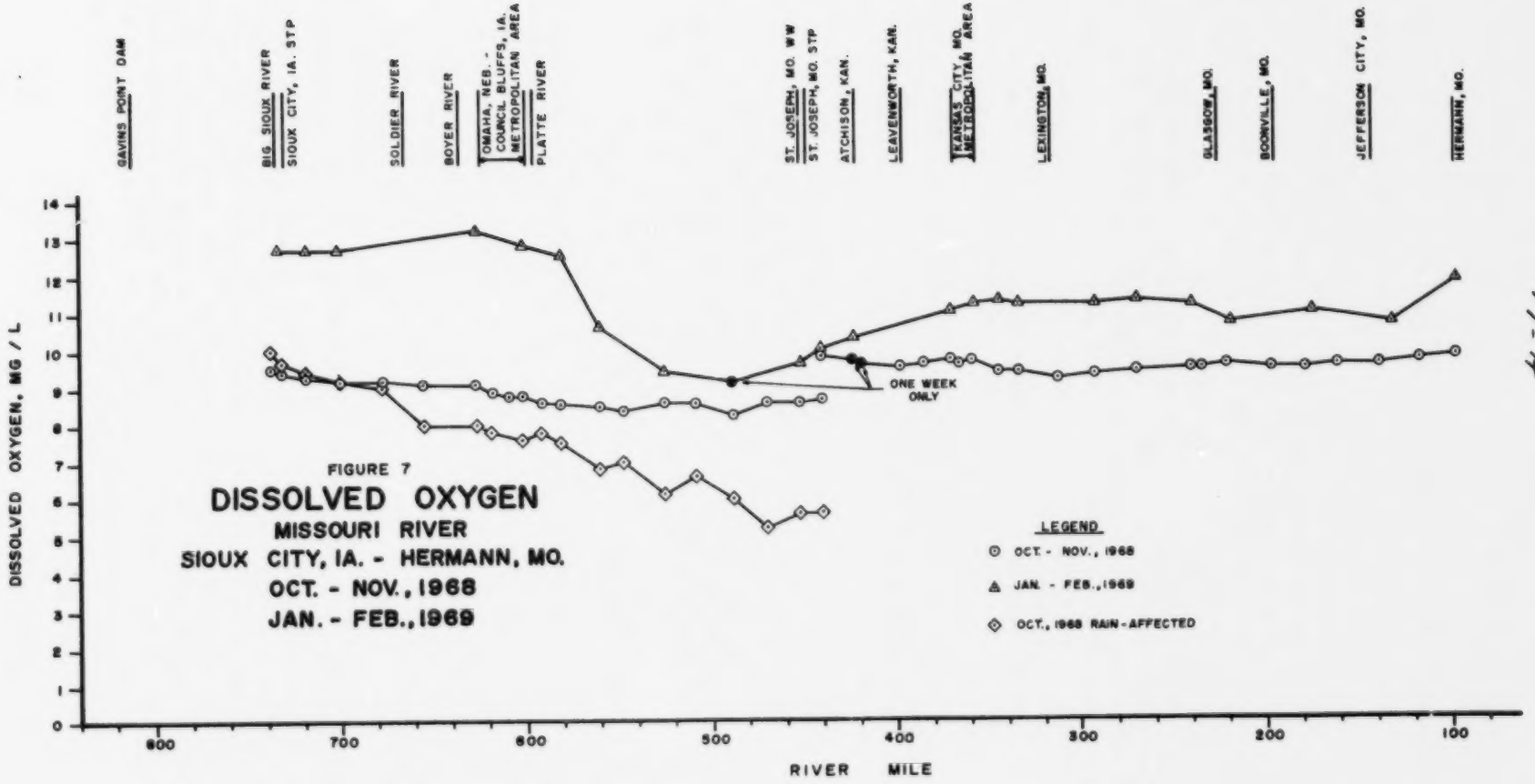


FIGURE 7

DISSOLVED OXYGEN

MISSOURI RIVER

SIOUX CITY, IA. - HERMANN, MO.

OCT. - NOV., 1968

JAN. - FEB., 1969

St. Joseph, Missouri - Hermann, Missouri

Average D.O. concentrations at Station M-27 (R.M. 440.3) were 1.1 mg/l greater during the second autumn survey than during the first autumn survey. This difference is partially accounted for by the lower average water temperature (16° C. vs 9° C.) in the latter survey period. This decrease in temperature increased oxygen saturation from 10.0 mg/l to 11.6 mg/l, a difference of 1.6 mg/l.

D.O. concentrations decreased slightly downstream from St. Joseph but exceeded 9.5 mg/l at all stations upstream from the Kansas City, Missouri water works intake. Downstream from the waste discharges in the Kansas City area, D.O. concentrations decreased to the lowest average of 9.2 mg/l at Station M-16 (R.M. 313.2) approximately 15 hours time-of-water travel downstream. D.O. concentrations recovered further downstream and averaged 9.8 mg/l at Station M-1 (R.M. 98.0) at Hermann.

During the winter survey, D.O. concentrations downstream from St. Joseph increased from 9.6 mg/l at Station M-28 (R.M. 452.3) to 11.2 mg/l at Station M-20A (R.M. 358.3). The warped flow conditions did not adversely affect D.O. concentrations. Downstream from the waste discharges in the Kansas City area, D.O. concentrations decreased slightly to 10.7 mg/l at Station M-9A (R.M. 219.2). The D.O. concentration exceeded this level at the remaining stations in the reach.

The D.O. criteria recommended in the NTAC report were exceeded at all stations during both survey periods.

TOTAL SUSPENDED SOLIDS

The total suspended solids concentration is a measure of the organic and inorganic particulate matter in water. The organic fraction consists of constituents such as, organic material from sewage, meat-packing waste, and suspended algae. The inorganic fraction consists of clays and silts washed from the land and carried by the river. The total suspended solids concentration is an indirect indicator of water clarity.

Gavins Point Dam - St. Joseph, Missouri

Water released from Gavins Point Dam (R.M. 811.0) averaged 45 mg/l total suspended solids (Figure 8). The concentration increased to 55 mg/l at Station M-52 (R.M. 736.0) upstream from Sioux City and remained relatively uniform at this level for 60 miles farther downstream. The total suspended solids increased irregularly downstream from Station M-46 until the highest average concentration in the reach of 278 mg/l occurred at Station M-32 (R.M. 525.1).

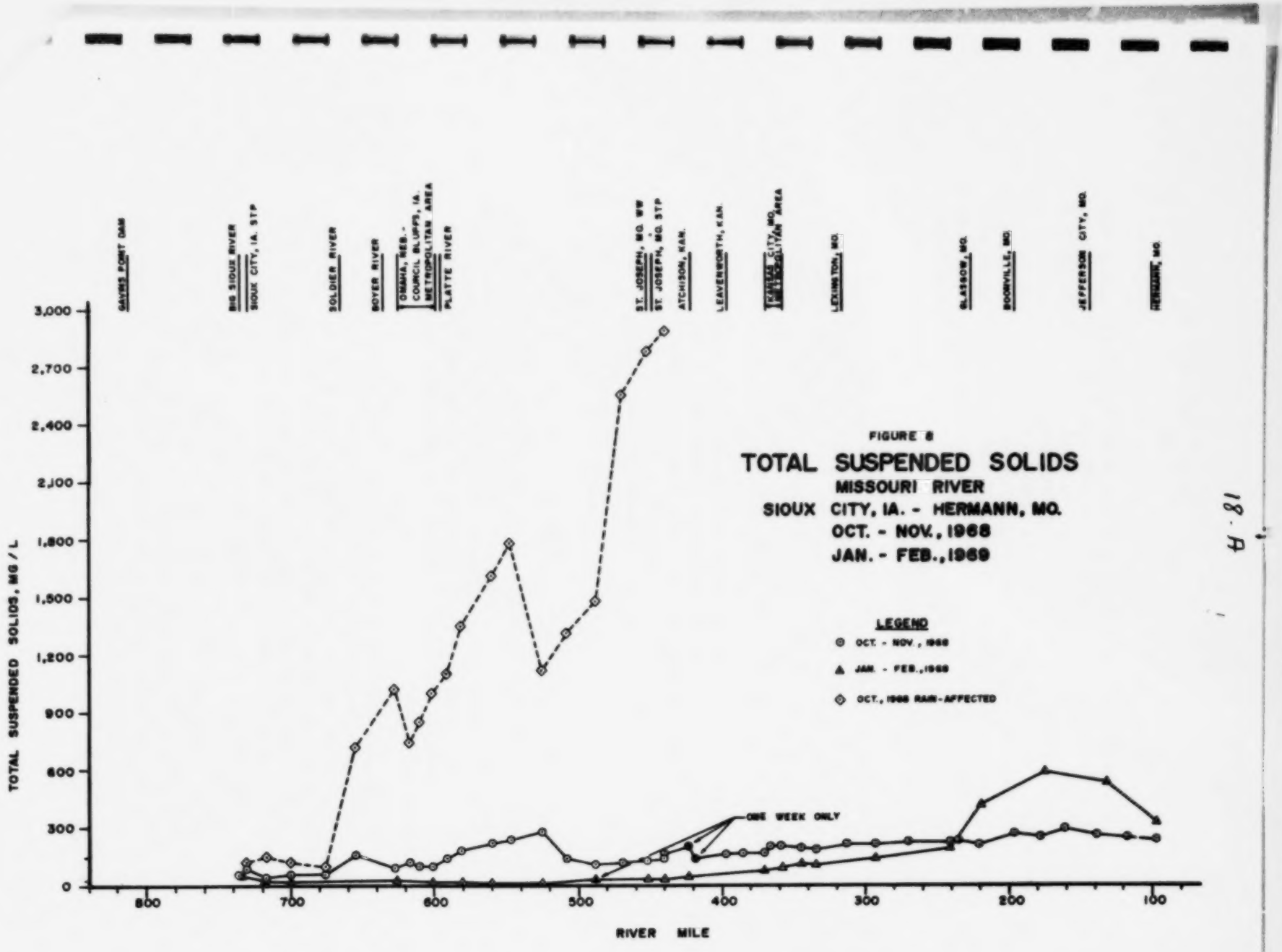


FIGURE 8

TOTAL SUSPENDED SOLIDS

MISSOURI RIVER

SIOUX CITY, IA. - HERMANN, MO.

OCT. - NOV., 1968

JAN. - FEB., 1969

H-81

The rain-affected two-day average total suspended solids concentrations were several times greater than the 8-day normal weather concentrations which averaged 715 mg/l at Station M-44 (R.M. 654.6) downstream from the Soldier River. The concentrations followed an irregular, although generally upward trend for the remaining stations in the reach. Beginning at the Omaha Metropolitan Utilities District (M.U.D.) water intake (Station M-42, R.M. 626.2), all of the remaining 13 downstream stations exceeded 700 mg/l total suspended solids, 10 stations exceeded 1,000 mg/l and two stations exceeded 2,000 mg/l. The highest average for the 2-day period was 2,780 mg/l at the St. Joseph Water Company intake (Station M-28, R.M. 452.3).

Upstream from the ice jams, the total suspended solids concentrations during the winter survey were quite low when compared with the autumn results. Water released from Gavins Point Dam (R.M. 811.0) contained only 2 mg/l which increased to 48 mg/l upstream from the major waste discharges in Sioux City. The nine remaining main stem stations in the reach had concentrations between 9 and 28 mg/l.

The clarity of the Missouri River during the winter survey when compared with the autumn survey is attributed to the frozen condition in the drainage basin. Tributary runoff carrying clay and silt particles was small. The damming effect of the ice jams reduced water velocity allowing sedimentation which contributed to water clarity.

St. Joseph, Missouri - Hermann, Missouri

The total suspended solids concentrations in this reach gradually increased in the downstream direction during the autumn survey. The average concentrations increased from 161 mg/l at Station M-27 (R.M. 440.3) downstream from St. Joseph, to the highest average of 297 mg/l at Station M-6 (R.M. 162.0). The concentration decreased slightly at Hermann.

Downstream from the ice jams during the winter survey, the total suspended solids concentrations increased. Concentrations increased from 29 mg/l at Station M-27 (R.M. 440.3) at the St. Joseph water intake to 233 mg/l at Station M-14 (R.M. 270.0). With the heavy rainfall and high runoff in the lower basin, concentrations reached the highest average of 596 mg/l at Station M-7A (R.M. 174.8).

NITROGEN(N)

Total nitrogen consists primarily of ammonia, nitrate, and organic forms. Nitrites are generally insignificant in streams and are not usually determined. Ammonia and nitrate forms of nitrogen are important nutrients required for green plant growth while ammonia and organic nitrogen (from protein-containing organic compounds)

compose most of the second stage or nitrogenuous BOD. Ammonia can be a problem at water treatment plants because of its high chlorine demand. Sources of nitrogen include waste discharges, runoff from chemically fertilized agricultural lands and feedlots, and to a minor extent, fixation of atmospheric nitrogen by certain biota.

Gavins Point Dam to St. Joseph, Missouri

During the normal weather survey, total nitrogen concentrations increased in the reach from Gavins Point Dam to Sioux City, decreased between Sioux City and Station M-44 (R.M. 654.6), but exhibited an increasing trend downstream from Omaha (Figure 9). The highest average concentration was 3.3 mg/l at Station M-27 (R.M. 440.3) at the lower end of the reach downstream from St. Joseph.

The composite samples from the rain-affected portion of the survey exhibited an erratic trend in total nitrogen concentrations but generally increased in the downstream direction. Total nitrogen concentrations were less than the 8-day normal-weather data for the Gavins Point Dam to Sioux City reach; approximately the same from Sioux City to the Soldier River; and greater than the normal weather concentrations downstream from the Soldier River. The highest total nitrogen concentration was 4.1 mg/l at Station M-29 (R.M. 469.0). Five of the main stem stations had concentrations of 3.0 mg/l or greater.

During the winter survey total nitrogen concentrations followed a similar pattern although concentrations were greater than during the autumn survey. The highest average concentration in the reach was 2.2 mg/l which occurred both at Sioux City and near St. Joseph.

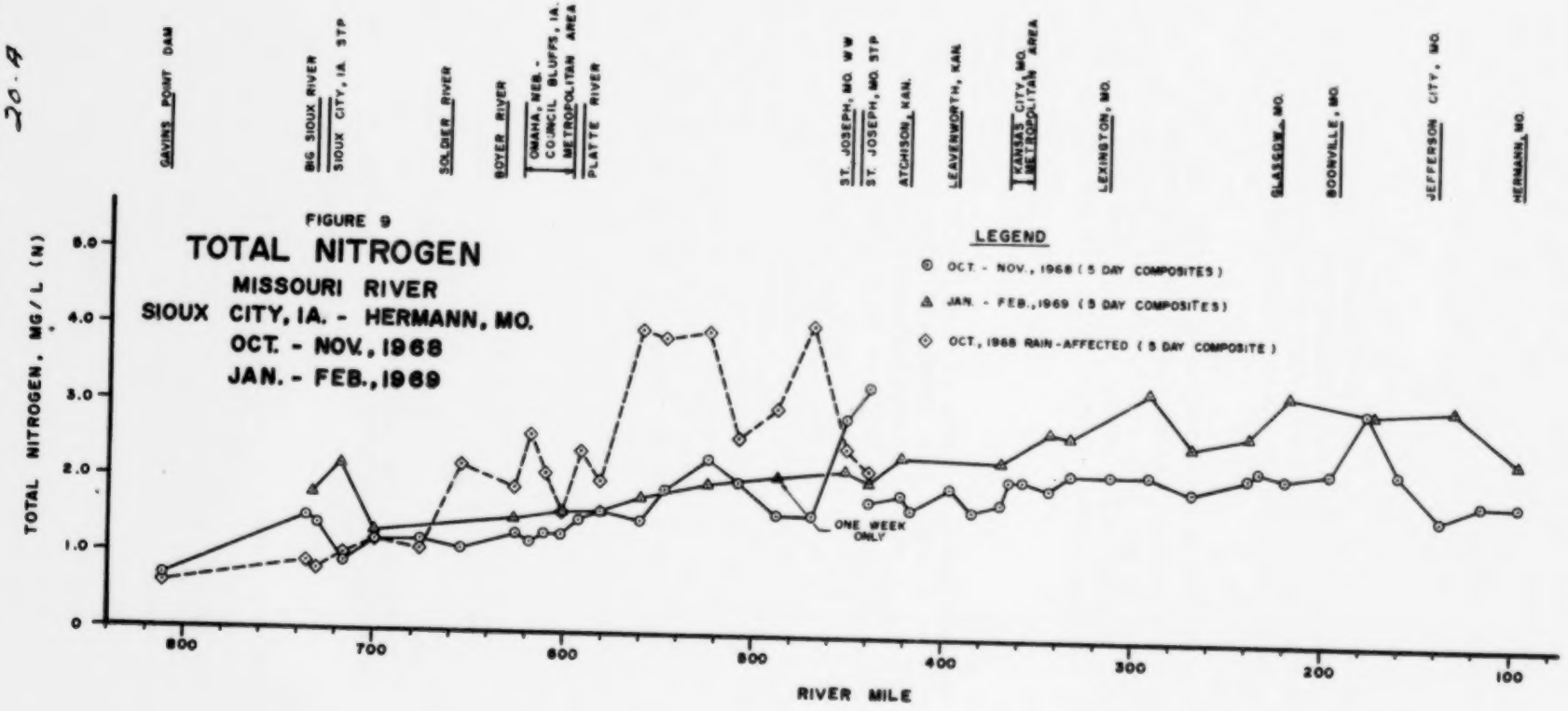
St. Joseph, Missouri - Hermann, Missouri

During the autumn survey, total nitrogen concentrations generally increased downstream from St. Joseph. The average concentration increased to 2.3 mg/l at Station M-8 (R.M. 197.2) at Boonville, Missouri. Following an apparently aberrant increase at Station M-7 (R.M. 179.0), the concentration decreased to 1.9 mg/l at Hermann.

Average concentrations during the winter survey followed a similar pattern with concentrations increasing downstream from St. Joseph. The highest average concentration was 3.3 mg/l at Station M-15 (R.M. 293.4) at Waverly, Missouri.

PHOSPHORUS(P)

Phosphorus is an important constituent in chemical fertilizers because of its requirement for plant growth. In streams, phosphorus can contribute to excessive algal growths which cause obnoxious tastes and odors in water supplies. Major sources of phosphorus include detergents in waste discharges and runoff from chemically fertilized agricultural lands.


GAVINS POINT DAM
BIG SIOUX RIVER
SIOUX CITY, IA. STP
SOLDIER RIVER
BOYER RIVER
OMAHA, NEB. - COUNCIL BLUFFS, IA. METROPOLITAN AREA
PLATTE RIVER
ST. JOSEPH, MO. WW
ST. JOSEPH, MO. STP
ATCHISON, KAN.
LEAVENWORTH, KAN.
KANSAS CITY, MO. METROPOLITAN AREA
LEXINGTON, MO.
GLASGOW, MO.
BOONVILLE, MO.
JEFFERSON CITY, MO.
HERMANN, MO.
FIGURE 9
TOTAL NITROGEN
MISSOURI RIVER
SIOUX CITY, IA. - HERMANN, MO.
OCT. - NOV., 1968
JAN. - FEB., 1969
LEGEND
OCT. - NOV., 1968 (5 DAY COMPOSITES)
JAN. - FEB., 1969 (5 DAY COMPOSITES)
OCT., 1968 RAIN-AFFECTED (5 DAY COMPOSITE)
ONE WEEK ONLY
TOTAL NITROGEN, MG/L (N)
0
1.0
2.0
3.0
4.0
5.0
800
700
600
500
400
300
200
100
RIVER MILE

Gavins Point Dam - St. Joseph, Missouri

Average total phosphorus concentrations were 0.04 mg/l in water released from Gavins Point Dam (R.M. 811.0) during the October 1968 survey (Figure 10).

Downstream from the Omaha-Council Bluffs area, total phosphorus ranged from 0.24 mg/l to 0.30 mg/l. This concentration includes significant contributions from Papillion Creek* and the Platte River (0.80 mg/l). The concentration remained essentially unchanged during the remainder of the reach.

Total phosphorus concentrations increased greatly at most stations in the composite samples collected during the rain-affected period which reflected runoff from agricultural lands. Concentrations increased irregularly downstream from Gavins Point Dam and reached the highest average of 0.92 mg/l at Station M-29 (R.M. 469.0).

During the winter survey, average total phosphorus concentrations had an irregular but generally increasing trend downstream from Sioux City (Figure 10). Concentrations were less than the autumn samples because of reduced contributions from tributaries and the frozen watershed.

St. Joseph, Missouri - Hermann, Missouri

Total phosphorus increased downstream from St. Joseph during the fall survey. Concentrations at 21 of the 22 stations ranged from 0.22 mg/l to 0.40 mg/l. One station had a concentration of 0.62 mg/l.

The winter survey results exhibited a similar pattern. Winter survey phosphorus concentrations were reduced upstream from Lexington, Missouri, but greater downstream. The large amount of rainfall and subsequent land runoff caused the increase downstream. The highest average concentration in the reach was 0.56 mg/l at Station M-5A (R.M. 132.0), two miles upstream from the Osage River.

WATER TEMPERATURE

During the upstream autumn survey period, average water temperatures during the 8-day normal period ranged from 14° C. upstream from Sioux City to 16° C. near the St. Joseph water intake (Appendix Table No. B-1). Average temperatures decreased during the 2-day rain-affected period in the upper reach. The temperature decreased to 10° C. at Sioux City.

Temperatures were reduced during the downstream autumn survey period. Temperatures ranged from 9° C. downstream from St. Joseph to 12° C. at Hermann. Sixteen of the 22 stations averaged 10° C.

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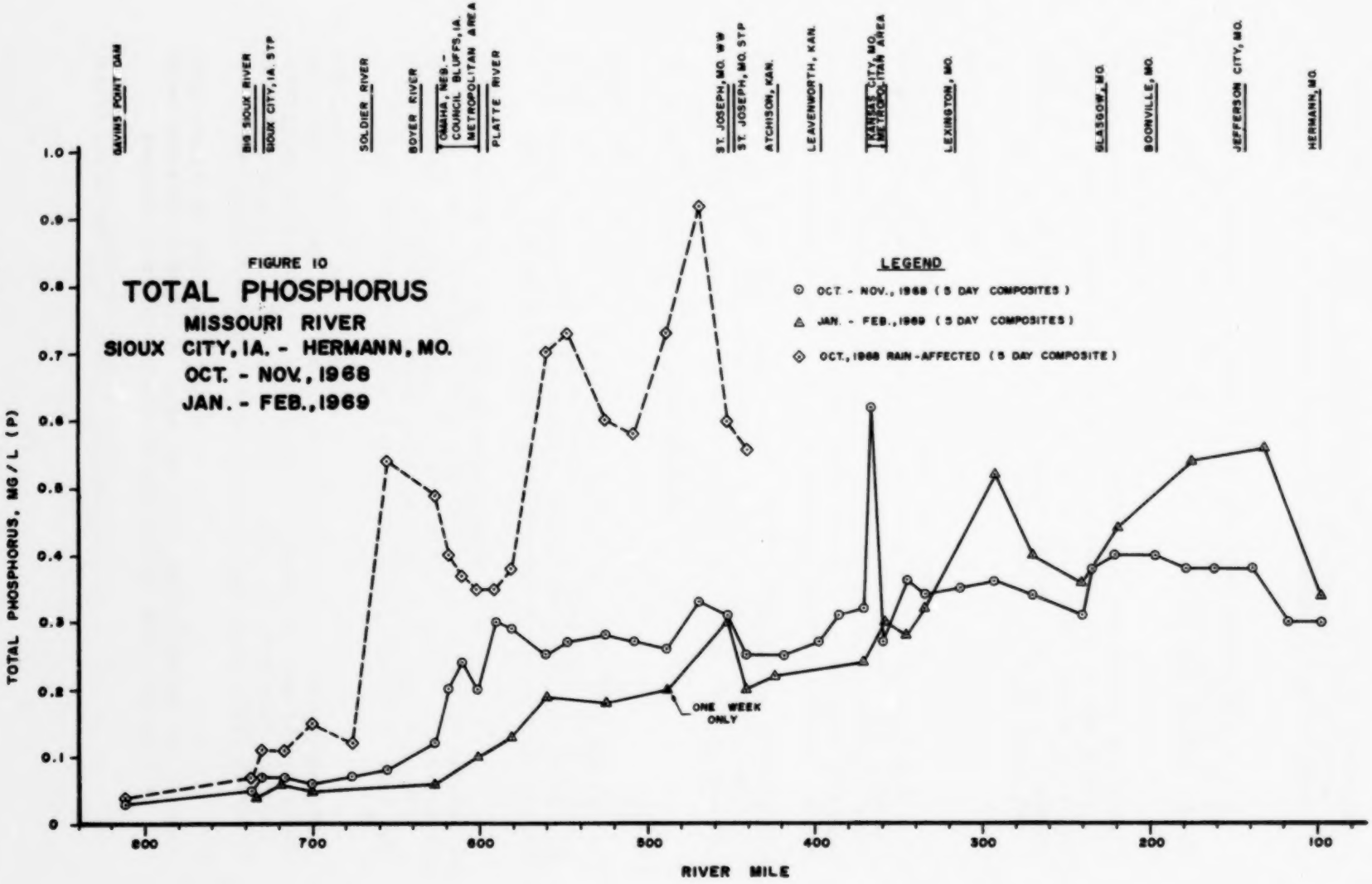
*Papillion Creek is composed primarily of sewage treatment plant effluent. The total phosphorus concentration during the winter survey was 6.45 mg/l. A similar concentration would be estimated for the autumn survey.


GAVINS POINT DAM
BIG SIOUX RIVER
SIOUX CITY, IA. STP
SOLDIER RIVER
BOYER RIVER
OMAHA, NEB. - COUNCIL BLUFFS, IA. METROPOLITAN AREA
PLATTE RIVER
ST. JOSEPH, MO. WW
ST. JOSEPH, MO. STP
ATCHISON, KAN.
LEAVENWORTH, KAN.
KANSAS CITY, MO. METROPOLITAN AREA
LEXINGTON, MO.
GLASGOW, MO.
BOONVILLE, MO.
JEFFERSON CITY, MO.
HERMANN, MO.
FIGURE 10
TOTAL PHOSPHORUS
MISSOURI RIVER
SIOUX CITY, IA. - HERMANN, MO.
OCT. - NOV., 1968
JAN. - FEB., 1969
LEGEND
OCT. - NOV., 1968 (5 DAY COMPOSITES)
JAN. - FEB., 1969 (5 DAY COMPOSITES)
OCT., 1968 RAIN-AFFECTED (5 DAY COMPOSITE)
ONE WEEK ONLY
TOTAL PHOSPHORUS, MG/L (P)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
800
700
600
500
400
300
200
100
RIVER MILE

Average water temperatures in the entire 700-mile reach were near 0° C. and reflected the low air temperatures and floating ice in the river during the winter survey. Four stations on one sampling run had a 1° - 2° C. difference in temperature (Stations M-26A, M-27, M-28 and M-30) from adjacent upstream and downstream stations. Eighteen of the remaining nineteen stations averaged 0° C. Station M-1 (R.M. 98.0) at Hermann averaged 1°C.

HYDROGEN ION CONCENTRATION(pH)

The NTAC Report on Water Quality Criteria recommends pH levels between 6.0 and 9.0 for maintenance of fish and other aquatic life. The waters of the Missouri River were within these limits.

The pH of the Missouri River was approximately 8.3 for most stations in the upstream reach during the autumn normal weather period(Appendix Table B-1). Average pH's varied from 8.1 to 8.6.

The pH decreased slightly at several stations during the 2-day rain-affected period. The lowest average pH during this period in the main stem Missouri River was 7.8 at Station M-30 (R.M. 488.3).

Downstream from St. Joseph the pH was generally 8.2 during the autumn survey. Average values ranged from 8.1 to 8.3 but 19 of the 22 main stem stations averaged 8.2.

Average pH's were generally lower during the winter survey than during the autumn 8-day normal weather period. In the reach from Sioux City to Atchison, Kansas, average pH values decreased from 8.1 (M-52A, R.M. 732.8) to 7.8 (Station M-26A, R.M. 422.5). After an increase to 8.0 at Station M-23 (R.M. 370.5) at the Kansas City, Missouri water intake, the pH generally decreased downstream to the lowest average of 7.6 at Station M-7A (R.M. 174.8).

ALKALINITY

The alkalinity of natural waters is primarily composed of bicarbonates, carbonates and hydroxide ions and is a measure of the buffer capacity (i.e., resistance to pH change with addition of either acid or base) of a water. It is generally reported as equivalent $CaCO_3$. The NTAC report recommends alkalinities greater than 20 mg/l for maintenance of fish and other aquatic life, and between 30 to a maximum of 400-500 mg/l for sources of public water supplies.

Alkalinity concentrations ranged from 160 mg/l to 197 mg/l in the upstream reach during the normal autumn weather period (Appendix Table No. B-1). Fourteen of 20 stations averaged between 160 - 170 mg/l. Concentrations decreased during the 2-day rain-affected period with a range of 114 mg/l to 180 mg/l. Sixteen of 19 stations averaged between 140 - 160 mg/l. During the autumn survey downstream from St. Joseph, alkalinities averaged between 162 mg/l and 181 mg/l with 20 to 22 stations between 170 - 181 mg/l.

Alkalinities during the winter survey averages between 165 mg/l and 192 mg/l from Sioux City to Station M-12 (R.M. 241.2). Fifteen of the 19 main stem stations averaged between 170 - 185 mg/l. Farther downstream, heavy rains and high flows resulted in a reduced alkalinity concentration of 116 mg/l at Hermann.

TOTAL DISSOLVED SOLIDS

Total dissolved solids are a measure of the inorganic salts present in a water although some soluble organic material may also be included. Excessive total dissolved solids are objectionable because of physiological effects, mineral tastes and economic effects such as corrosion.

The NDAC criteria and the PHS Drinking Water Standards* recommend that total dissolved solids not exceed 500 mg/l for sources of public drinking water supply. Several stations on the Missouri River exceeded this concentration.

Total dissolved solids concentrations during the normal autumn weather period ranged from 468 mg/l to 645 mg/l upstream from St. Joseph (Appendix Table No. B-1). Of the 20 main stem stations sampled, fourteen stations averaged less than 500 mg/l and 19 stations less than 552 mg/l. Concentrations were reduced during the 2-day rain-affected period when results ranged from 198 mg/l to 516 mg/l. Eleven of 16 stations averaged less than 400 mg/l.

Total dissolved solids concentrations ranged from 375 mg/l to 504 mg/l downstream from St. Joseph during the autumn survey. Twenty-one of 22 stations averaged less than 500 mg/l with 14 between 450 mg/l and 500 mg/l.

During the winter survey, the concentration of total dissolved solids ranged from 480 mg/l to 653 mg/l except at the four most downstream stations (M-9A, M-7A, M-5A and M-1). Of the 20 stations sampled, eight ranged from 480 mg/l to 500 mg/l, seven exceeded the 500 mg/l criterion and ranged between 500 mg/l and 550 mg/l. Concentrations at the lower four stations were less than upstream and ranged from 403 mg/l to 254 mg/l. The decrease was caused by the heavy rains and high runoff.

SULFATES

The significance of the sulfate ion in drinking water is essentially the same as total dissolved solids. The Public Health Service Drinking Water Standards recommend limiting sulfate concentrations to 250 mg/l. Average concentrations did not exceed this standard

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* Anon. Public Health Service Drinking Water Standards, DHEW, Public Health Service Publ. No. 956 (1962).

in the Missouri River although concentrations in excess of 200 mg/l occurred.

Sulfate concentrations ranged from 164 mg/l to 220 mg/l in the upper reach during the autumn normal weather period (Appendix Table No. B-1). Nine of the 20 stations in this reach averaged over 200 mg/l. Concentrations were similarly distributed during the 2-day rain-affected period although 7 stations had higher results than during the normal period.

Sulfate concentrations ranged from 113 mg/l to 203 mg/l downstream from St. Joseph during the autumn survey. Fifteen stations averaged less than 190 mg/l. Concentrations had a generally decreasing pattern downstream from Kansas City.

During the winter survey, sulfate concentration trends were similar to those of the autumn survey upstream from Station M-9A (R.M. 219.2). Concentrations ranged from 150 mg/l to 224 mg/l. A downward trend occurred between Stations M-9A and M-1 because of dilution from heavy tributary runoff.

TOTAL ORGANIC CARBON

The total organic carbon test is a measure of the total organic matter in water and comprises the theoretical, maximum carbonaceous oxygen demand. The test measures organic carbon in materials contained in waste discharges, naturally occurring organic materials such as lignins, and living organisms such as algae and bacteria, all of which are transported by a stream.

The total organic carbon concentrations were less than 10 mg/l* during the autumn normal weather period in the upstream reaches (Figure 11). Concentrations increased irregularly from 5 mg/l at Gavins Point Dam to concentrations of 8 - 9 mg/l near St. Joseph. Concentrations downstream from Sioux City were approximately two times greater during the rain-affected period when compared to the normal weather period. Two stations had concentrations greater than 20 mg/l and seven stations exceeded 15 mg/l.

Downstream from St. Joseph during the autumn survey, total organic carbon concentrations ranged from 8 mg/l to 11 mg/l with no definite trend evident. Five stations averaged 8 mg/l, 9 stations averaged 9 mg/l, 7 stations averaged 10 mg/l and 1 station averaged 11 mg/l.

Total organic carbon concentrations during the winter survey ranged from 5 mg/l at Sioux City (Station M-52A, R.M. 732.8) to 7 mg/l at the Kansas City, Missouri water intake (Station M-23, R.M. 370.4). Downstream from the Kansas River and the Kansas City area, concentrations generally increased. The highest average of 16 mg/l occurred at Station M-5A (R.M. 132.0).

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* Except for an aberrant concentration of 135 mg/l at Station M-48.

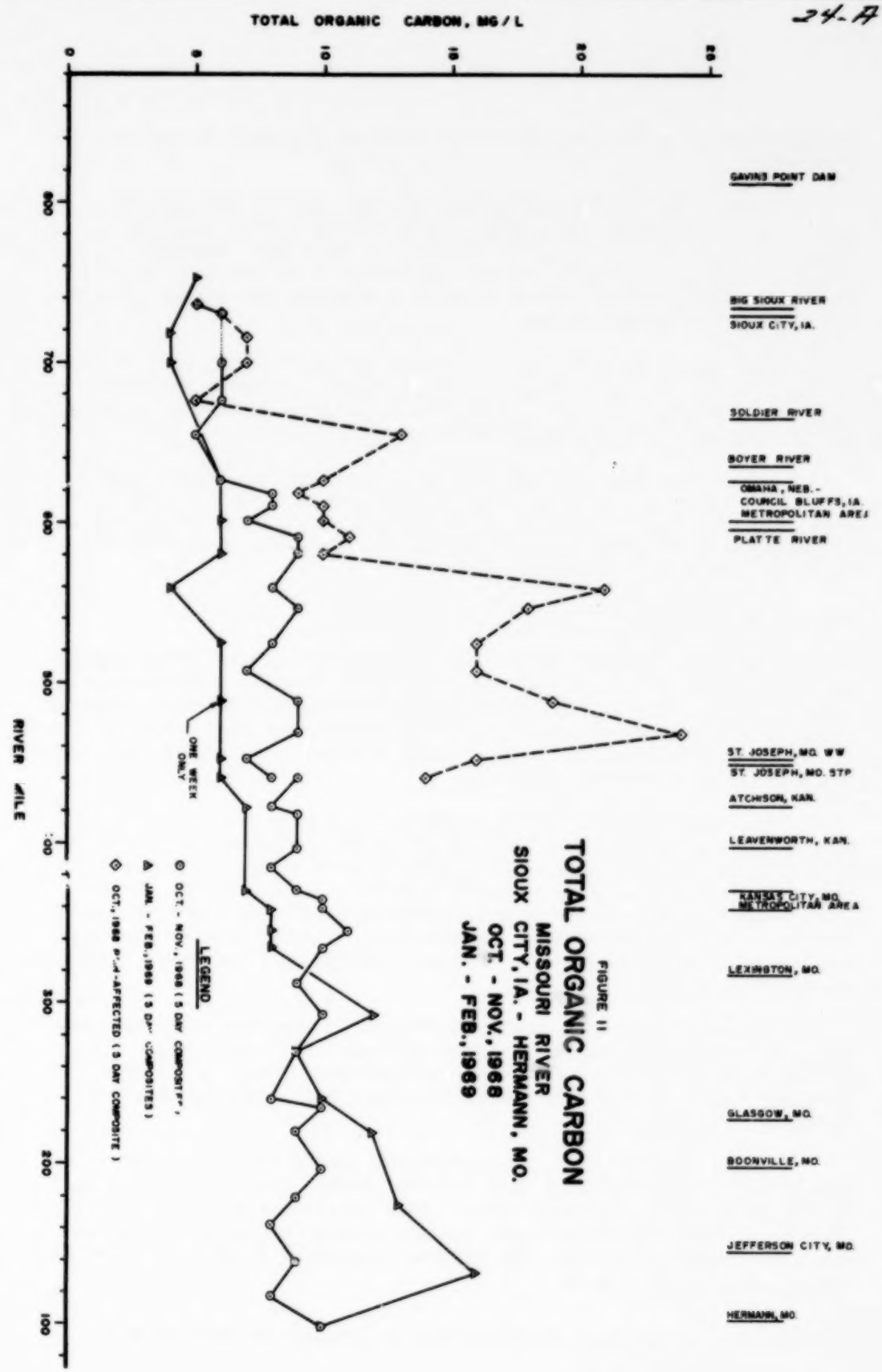

FIGURE 11

TOTAL ORGANIC CARBON

MISSOURI RIVER
SIOUX CITY, IA. - HERMANN, MO.
OCT. - NOV., 1968
JAN. - FEB., 1969

SOLUBLE METALS

Eleven different metal analyses were performed during the surveys of the Missouri River. All determinations were on the filtrate from samples and thus indicate soluble concentrations. Of these metals, several were absent at all sample stations in detectable concentrations: barium (< 1.0 mg/1), cadmium (< 0.02 mg/1), total chromium (< 0.02 mg/1), copper (< 0.05 mg/1), and nickel (< 0.10 mg/1) (Appendix Table No. B-10).

During the autumn survey, detectable concentrations of boron and iron occurred. Approximately 0.12 mg/1 of boron occurred upstream from St. Joseph. Downstream concentrations decreased from 0.34 at Station M-24 (R.M. 384.9) to less than 0.02 mg/1 at Hermann (Station M-1 - R.M. 98.0). A soluble iron concentration of 0.60 mg/1 for the second 5-day composite was detected at Station M-39 (R.M. 610.5) just downstream from the Missouri River STP discharge in Omaha.

Detectable concentrations of iron, manganese, boron, lead, and arsenic occurred during the winter survey. Soluble iron concentrations ranged from < 0.1 mg/1 to 0.3 mg/1. Five of 12 stations had measurable concentrations. Manganese concentrations ranged from < 0.02 mg/1 to 0.10 mg/1. Eleven of the 12 stations sampled had positive results. Boron concentrations were detected at all stations selected for analysis. Concentrations ranged from 0.08 mg/1 to 0.12 mg/1. The average concentration of lead at Station M-48A (R.M. 718.3) was 0.085 mg/1 which exceeded the PHS Drinking Water Standard of 0.05 mg/1. The source of lead was not determined. The largest arsenic concentration in a discrete sample was 0.035 mg/1 and occurred upstream from Sioux City at Station M-42 (R.M. 626.2). Detectable concentrations also occurred at Station M-23 (R.M. 370.5) and M-38 (R.M. 601.3).

CYANIDE

Cyanides are synthetic organic compounds which have acute toxicity. The PHS Drinking Water Standards have established a limit of 200 µg/1 for cyanides. Since there are no naturally occurring cyanides, their presence indicates a waste source containing the constituent.

Positive cyanide results (more than 1.0 µg/1) were obtained at six of the seven stations sampled between Sioux City and St. Joseph during the autumn survey (Appendix Table No. B-13). Samples from three of eight stations were positive downstream from St. Joseph.

Maximum concentrations during the autumn surveys occurred during the 2-day rain-affected period when the highest single result was 15.2 µg/1 at Station M-33 (R.M. 546.7). Four stations in this reach exceeded 10 µg/1 during this wet period. Downstream from St. Joseph, the highest single concentration of 7.0 µg/1 occurred downstream from the Kansas River at Station M-20.

During the winter survey measurable cyanide results were obtained at 10 of the 12 stations sampled. The maximum concentration was 7.7 µg/l at the Omaha M.U.D. water intake.

TOTAL ORGANIC CHLORINE

Total organic chlorine indicates the presence of organic chlorine-bearing compounds which are principally chlorinated hydrocarbon pesticides in the absence of chlorinated waste discharges. Although the test is non-specific as to which pesticides or other compounds are present, it does indicate the presence of the general group.

Total organic chlorine concentrations were generally higher upstream from St. Joseph than downstream during the autumn surveys (Appendix Table No. B-13). The highest concentration was 264.3 µg/l downstream from the Omaha area waste discharges. Downstream from St. Joseph concentrations ranged from 30.6 µg/l to 98.7 µg/l.

The cause of the higher concentrations of organic chlorine upstream may be related to pesticide use on the extensive farmland in this area (also irrigation upstream from study area) as well as use for insect vector control in feedlot operations.

Total organic chlorine concentrations exhibited no definite pattern during the winter survey. Tributary runoff for most of the basin was small (upstream from Jefferson City, Missouri) because of the frozen conditions of the watershed. Pesticides, also, had not been applied for several months. These levels would represent concentrations in upstream storage reservoirs of both the Missouri and Kansas Rivers. Concentrations ranged from 22.2 µg/l to 74.4 µg/l.

GREASE

The determination of grease by the Standard Methods procedure includes fats, waxes, oils and other non-volatile materials which are soluble in hexane. Grease is an obnoxious compound in water because of the unsightly surface scum formed, and because it causes problems in water supplies.

Because of previous difficulties reported by water supplies downstream from the Omaha area (principally, St. Joseph), grease concentrations were determined for waste discharges in the Omaha area and Sioux City. Downstream from the Omaha area and continuing past the St. Joseph water intake "grease balls" were observed floating on the water surface during the autumn survey. Measurement of grease from the Iowa Beef Packers Plant in Dakota City, Nebraska was determined at a later time by the Missouri Basin Region Results of these analyses (Table No. 4) indicate grease concentrations in packinghouse waste and in primary treated effluent.

TABLE 4

GREASE

MISSOURI RIVER SURVEYS

Monroe St.- S. Omaha Sewer Composite mg/l	Missouri R. Sewg. Trmnt. Plt. mg/l	Council Bluffs Iowa STP Effluent mg/l	Sioux City Iowa STP Effluent mg/l	Ia. Bf.Pkrs. Dakota City Nebraska mg/l
		OCTOBER-NOVEMBER		
299	-	-	17	-
		JANUARY-FEBRUARY		
-	26	31	38	263(1)

(1) Average of 3 samples collected on March 27-28, 1969 when Grease removal was not in operation.

21.4

Average Grease concentrations in untreated packinghouse waste ranged from 260 - 300 mg/l; that from primary treated effluents ranged from 15 - 40 mg/l.

RADIOACTIVITY LEVELS

Radiological analyses were performed only during the autumn surveys. The naturally occurring radionuclides uranium (U-235 and U-238), radium -226, thorium -232 and total alpha thorium; and the "fission" product strontium-90 were determined. Although not an inclusive list of analyses, this series of naturally occurring nuclides allows an estimate of the natural background levels. Strontium-90 occurs because of past atmospheric nuclear weapons testing and is significant for physiological reasons because its chemical properties are similar to calcium.

As shown in Table No. 5, dissolved radionuclide concentrations in the Missouri River and selected tributaries were substantially lower than the permissible criteria recommended by NTAC for sources of water supply. In the main stem of the Missouri River, at the four stations sampled, uranium concentrations varied from 2.5 µg/l to 4.3 µg/l; radium -226 concentrations from 0.02 pc/l to 0.07 pc/l; and strontium-90 concentrations from 1.5 pc/l to 2.2 pc/l. Thorium -232 concentrations were less than the detection limits of the analytical method.

Gross alpha concentrations for various stream locations in the country are reported in Radiological Health Data and Reports (RHD&R). For the period July to December, 1968 concentrations averaged 2.9 pc/l for the Missouri River at the Missouri City and St. Joseph, Missouri stations. Total alpha concentrations during the autumn survey were calculated from the uranium (after conversion to pc/l*) and radium - 226 concentrations. The concentration calculated by this method was 2.5 pc/l which is very close to the value reported in RHD&R. Thus, the naturally-occurring radionuclides are primarily responsible for the observed autumn concentrations.

The headwaters of the Platte River drain the uranium enriched areas of Colorado and transport higher concentrations of uranium than other Missouri River tributary streams. The uranium concentration was 6.4 µg/l but still much less than the NTAC criterion (Table No. 5).

The strontium-90 concentrations averaged about 1.8 pc/l during the autumn surveys. Strontium-90 concentrations in water have declined with the reduction in atmospheric nuclear testing. In the period from July to September, 1967 RHD&R reported concentrations of 3.0 pc/l and 3.2 pc/l respectively for Missouri City and St. Joseph. The autumn data reflect the decline in the intervening time period.

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* For uranium, 1 µg equals 0.668 pc assuming U-234 equilibrium.

TABLE NO. 5

National Technical Advisory Committee

Recommended Surface Water Radiological Criteria
for
Public Water Supplies

Constituent	Permissible[1] Criteria	Desirable[2] Criteria
Uranium	4.4 mg/l	Absent[3]
Radium-226	3 pc/l	< 1 pc/l
Strontium-90	10 pc/l	< 2 pc/l

(1) Concentrations in raw surface waters which allow the production of a safe, clear, potable, aesthetically pleasing, and acceptable public water supply which meets the limits of the Public Health Service Drinking Water Standards.

(2) Concentrations in raw surface waters that represent high quality water in all respects for use as public water supplies.

(3) Not detectable by the most sensitive analytical procedure in "Standard Methods" or other approved procedure.

BOTTOM ANIMALS*

Many invertebrate animals are found living on the beds of rivers. In a clean water environment, this community includes numerous kinds of pollution-sensitive animals which serve as food organisms for desirable game fish. Pollution-tolerant organisms are present but are few in number. As the environment receives increasing amounts of organic pollution, clean water animals are reduced or eliminated from the community in the order of their sensitivity to degraded water quality. This adverse change in the bottom-associated community is indicative of the extent of pollution. Further evidence of organic pollution is indicated by increases in floating solids and in the formation of sludge deposits in slack water areas behind man-made or naturally occurring obstructions. The sludge may decompose and produce obnoxious gases and remove dissolved oxygen from the overlying flowing water.

The river upstream from Sioux City at Station M-52 (R.M. 736) and downstream to the Omaha, Missouri River waste treatment plant (R.M. 612), supported a stream bed animal community indicative of unpolluted water (Figures 12 and 13, and Table 6). Clean-water stoneflies, mayflies, and caddisflies were the predominant kinds of bottom organisms throughout most of this reach (Appendix Table No. B-16). The number of pollution tolerant forms remained proportionately lower than sensitive kinds except in the reach bordered by Sioux City, Iowa and Dakota City, Nebraska at Station M-50 (R.M. 730). Floating solids consisting of manure, chopped garbage and similar materials were observed. These were found upstream from the municipal waste treatment plants, and thus, originate from untreated waste sources.

Tributaries examined in this reach indicated polluted conditions. Flows from these streams were low in volume and the degraded water entering had no observable effect on the Missouri River.

Downstream from Omaha-Council Bluffs, adverse effects of discharged wastes were discernible for more than 166 miles. Floating solids were evident and unsightly globular masses of grease, chunks of animal fat, and paunch manure accumulated in eddy areas. Clean-water animals were destroyed for 54 miles downstream to Station M-33 (R.M. 547) except at Barlett, Iowa at Station M-35 (R.M. 581) where an aberrant increase in kinds of sensitive and tolerant forms occurred (Figure 13). At Bartlett, available evidence indicated that the animals found were from the Platte River. The Platte River enters upstream, and could have carried invertebrates into the Missouri River. The community found at Station M-35 (R.M. 581) was composed

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*The bottom animal community was sampled from locations behind rock jetties and other backwater areas. The bottom animal identifications discussed are for these areas only and are not intended to represent conditions for the entire channel cross sections. (See the Section on Methods.)

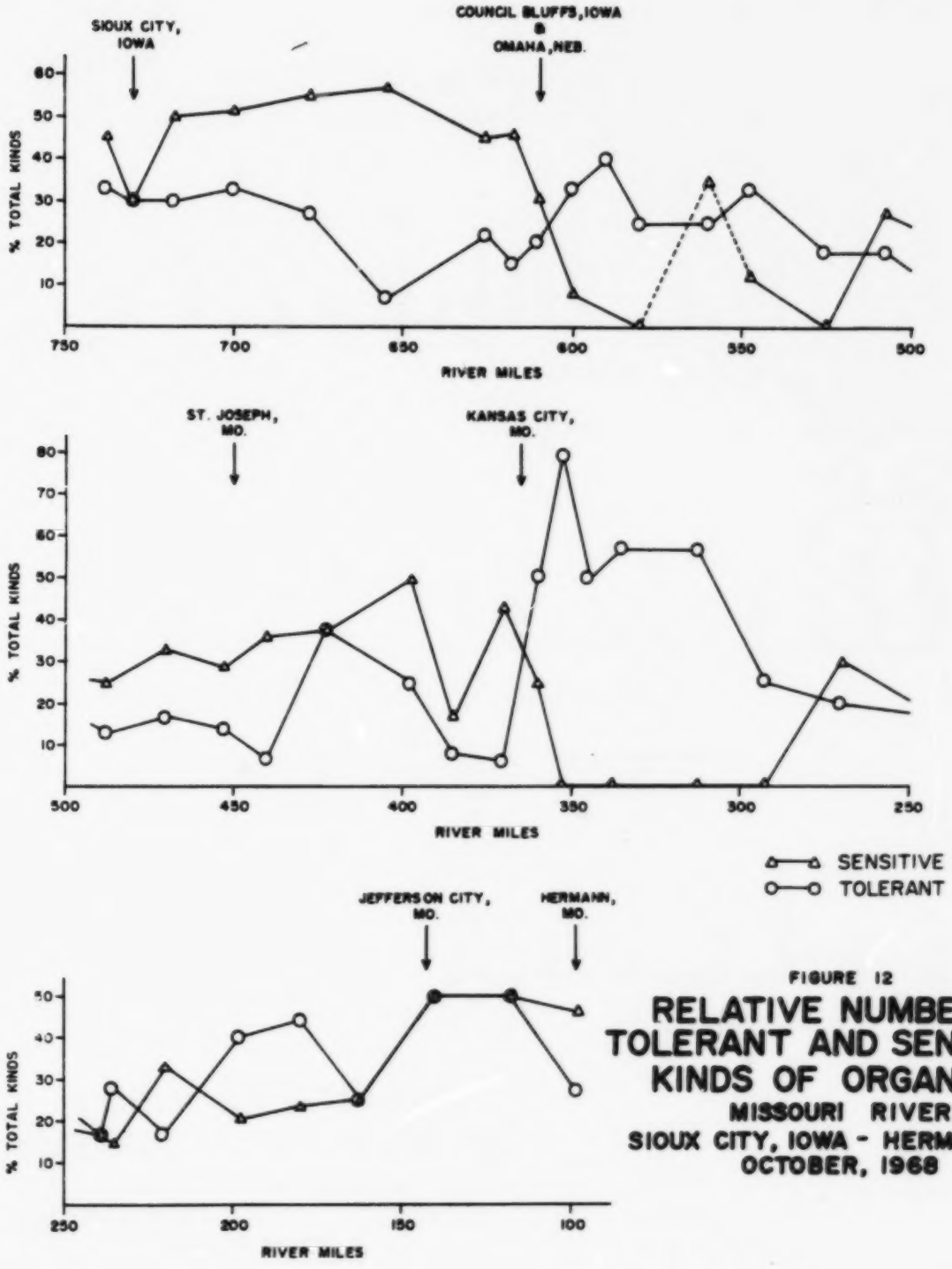


FIGURE 12

RELATIVE NUMBER OF TOLERANT AND SENSITIVE KINDS OF ORGANISMS

MISSOURI RIVER

SIOUX CITY, IOWA - HERMANN, MO.

OCTOBER, 1968

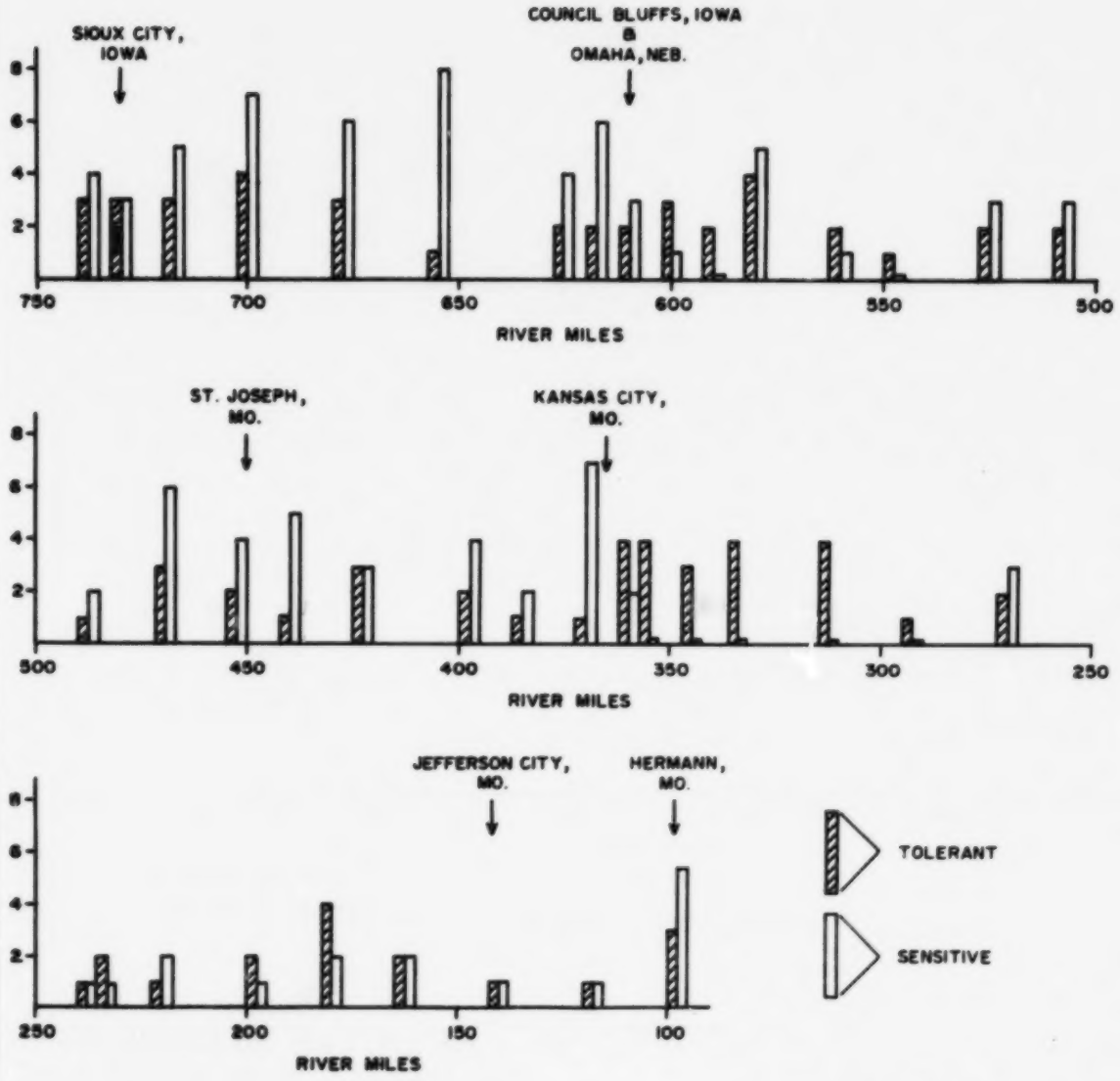


FIGURE 13

NUMBER OF KINDS OF BOTTOM ORGANISMS

MISSOURI RIVER

SIOUX CITY, IOWA - HERMANN, MO.

OCTOBER, 1968

of nearly the same kinds as found in the Platte River. These particular forms were not found at adjacent Missouri River stations and thus would not be indicative of Missouri River water quality at this station.

Downstream from Brownville, Nebraska, at Station M-32 (R.M. 525), the number of pollution sensitive kinds of bottom animals were proportionately greater than pollution tolerant animals (Figure 13). This increase resulted from water quality improvement caused by natural removal of organic settleable solids contained in upstream wastes so that backwater bottom conditions improved. The river continued to support a community of benthic animals indicative of good quality water downstream to Kansas City. Slowly decomposing grease globs remaining in these waters did not induce changes sufficient to affect the aquatic life but were aesthetically objectionable for recreation and water supply uses.

Pile dikes at Station M-23 (R.M. 370) immediately upstream from the Kansas City area supported a diverse bottom fauna. The community contained an assemblage of 7 pollution sensitive and 1 pollution tolerant form. The number of animal kinds present and the composition of the bottom-associated organisms was indicative of unpolluted water (Table 6).

Approximately 11 river miles downstream at Station M-20 (R.M. 359), the number of pollution sensitive forms decreased from 7 to 2 kinds and the tolerant forms increased from 1 to 4. Pollution tolerant sludgeworms, pulmonate snails and leeches predominated which indicated degraded water quality. Sensitive forms such as, mayflies were reduced in number of kinds; caddisflies were eliminated. Large quantities of floating and suspended material and oil were observed at this station.

Downstream from the Blue River confluence, all pollution sensitive organisms were eliminated and replaced by more pollution tolerant forms (R.M. 356). Restriction of the diversity of forms to those that are most tolerant indicated gross organic pollution. The accumulation of organic sludge on the pile dikes, and in the backwater areas, limited the available habitat to tolerant forms. This condition persisted for approximately 63 miles downstream to Waverly, Missouri at Station M-15 (R.M. 293).

Downstream from Waverly from Station M-14 (R.M. 270) to Station M-8 (R.M. 197), the appearance of pollution sensitive forms indicated slight recovery from pollution. However, this portion of the river contained animal communities comprised of near equal varieties of pollution sensitive and tolerant animals. This is indicative of moderate pollution when compared to upstream clean-water areas where the variety of sensitive forms were four to five times as numerous as the tolerant ones.

From Lupus, Missouri, at Station M-7 (R.M. 179) downstream to Hermann, Missouri, at Station M-1 (R.M. 98), large numbers of pollution sensitive burrowing mayflies were collected. The presence of these clean water organisms was an indication of improved water quality in this reach.

SUSPENDED ALGAE

The suspended algal community, phytoplankton, in large flowing streams originate in lakes and backwaters associated with the streams. This community is affected by environmental factors characteristic of each stream such as: turbidity, water velocity, and available inorganic nutrients. Turbidity restricts the amount of light that penetrates the water and thus restricts algal photosynthesis.

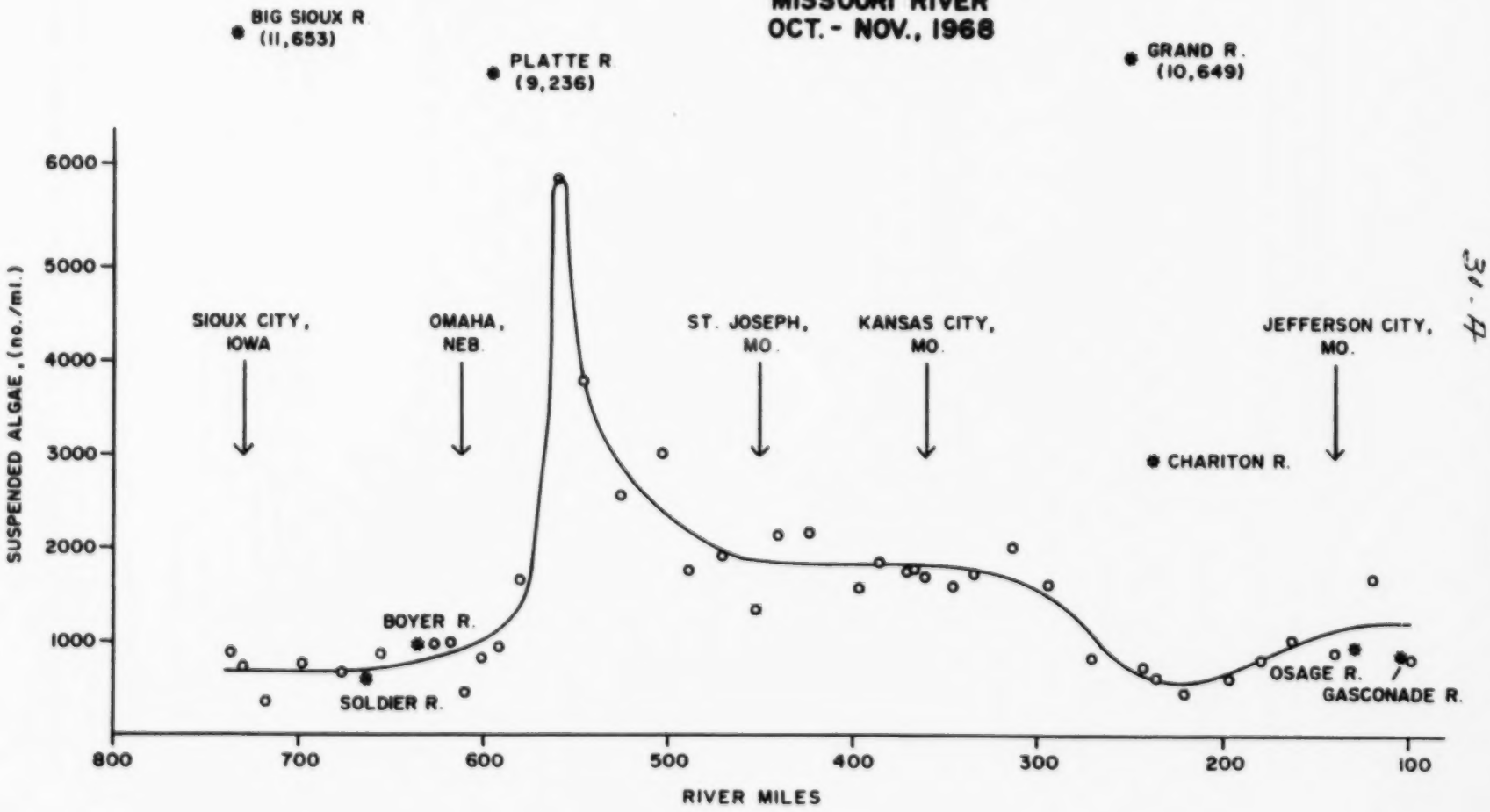
Water velocity also affects phytoplankton which are principally static water organisms. Their presence in flowing water results from facultative adaptation. Swift turbulent currents are detrimental to many of these fragile organisms because of the abrasive action of suspended solids and because the organism is prevented from maintaining a position for optimum light. Increased inorganic nutrients may produce increases in numbers and change the kinds of algae present, unless physical factors are limiting.

In the Missouri River, a combination of a swift current, high turbidity, and lack of adjoining still water environments (due to channelization of the river), tend to limit the phytoplankton community to low numbers.

Suspended algae ranged in numbers from 870 cells per milliliter (ml) to 1,000 cells per ml in the river reach from Station M-52 (R.M. 736.0) at Sioux City to Omaha-Council Bluffs at Station M-41 (R.M. 618.3) (Figure 14). Downstream from Omaha-Council Bluffs, beginning at Station M-38 (R.M. 601.3), the algal population started to increase and attained a high of 6,000 cells per ml at Station M-34 (R.M. 559.7) which was approximately a sixfold increase. This increase is attributed to nutrients being discharged to the river. Downstream from this point to St. Joseph, Missouri, at Station M-28 (R.M. 452.3), the population of algae gradually declined. From Station M-28 at St. Joseph, Missouri to a point downstream from Kansas City at Station M-15 (R.M. 293.4), the algal population ranged from 1300 to 2000 cells per ml. The algal population of 2,000 per ml in this reach would have declined to numbers equal to, or less than, those noted upstream from Omaha except for the nutrients discharged from cities adjoining the river. Downstream, the effects of current, turbidity and suspended solids reduced the population to 500 cells per ml at Station M-9 (R.M. 221). The algal population increased slightly to 1,000 cells per ml farther downstream at Station M-6 (R.M. 162.0).

FIGURE 14

SUSPENDED ALGAE
(number per ml.)
MISSOURI RIVER
OCT. - NOV., 1968



31-A

Tributary streams contained high populations of phytoplankton but stream flows were too small to contribute significant quantities of algae to the Missouri River algal populations.

TRIBUTARY STREAMS

Twelve tributary streams were sampled either for chemical and bacteriological analyses or biological analyses, or both, near their confluences with the Missouri River during the autumn survey (Table 6, 7 and Appendix B). Two of these (Papillion Creek and the Platte River) were again sampled during the winter survey.

Big Sioux River

This stream flows into the Missouri River just upstream from Sioux City, Iowa, and forms the South Dakota-Iowa state line. Only four kinds of pollution tolerant and one kind of pollution sensitive animals were found. The bottom contained deposits of organic material and oil. During the two-day, rain-affected period, DO's decreased by fifty percent (from 12.0 mg/l to 6.0 mg/l) and fecal coliform bacteria increased from 110 MPN/100 ml to 4,000 MPN/100 ml.

Floyd River

The bottom of this stream was covered with organic solids, including manure, and exuded the rotten egg odor of hydrogen sulfide. Water quality was degraded so severely that only one kind of pollution tolerant bottom animal could inhabit these waters.

Soldier River

The water quality in this stream was greatly affected by rainfall. During the rain-affected period, geometric mean fecal coliform bacterial densities increased from 4,000 MPN/100 ml to 2,000,000 MPN/100 ml, and suspended solids from 10 mg/l to 3,530 mg/l. The stream supported only two kinds of pollution tolerant bottom organisms and no clean water kinds.

Boyer River

The water quality of the Boyer River was also adversely affected during the rainy period. Fecal coliform densities increased from a mean of 20,500 MPN/100 ml to 1,500,000 MPN/100 ml, and the BOD_5 increased to 14 mg/l. The sandy bottom of the stream supported only one kind of sensitive clean water organism, and three kinds of tolerant bottom organisms.

Papillion Creek

A primary source of flow in this stream is the treated sewage discharges from Omaha's Papillion Creek sewage treatment plant,

TABLE 6

NUMBER OF KINDS OF

BOTTOM-ASSOCIATED ANIMALS

MISSOURI RIVER

OCTOBER, 1968

LOCATION Corresponding Water Quality Station	River Mile	Pollution Sensitive Organisms	Pollution Intermediately Sensitive Organisms	Pollution Tolerant Organisms	Total Number of Kinds
MISSOURI RIVER					
M-52	736	4	?	3	9
M-50	730	3	4	3	10
M-48	717	5	?	3	10
M-47	699	7	?	4	13
M-46	676	6	?	3	11
M-44	655	8	5	1	14
M-42	626	4	3	?	9
M-41	618	6	5	?	13
M-39	610	3	4	?	9
M-38	601	1	9	3	13
M-36	591	0	3	?	5
M-35	581	5	7	4	16
M-34	560	1	5	?	8
M-33	547	0	?	1	3
M-32	525	3	6	?	11
M-31	507	3	6	?	11
M-30	488	?	4	1	7
M-29	469	6	9	3	18
M-28	452	4	8	?	14
M-27	440	5	8	1	14
M-26	423	3	?	3	8
M-25	397	4	1	?	7
M-24	385	?	9	1	12
M-23	370	7	8	1	16
M-20	359	7	?	4	8
-	356	0	1	4	5
M-18	345	0	3	3	6
M-17	334	0	3	4	7
M-16	313	0	3	4	7
M-15	293	0	3	1	4
M-14	270	3	5	?	10
M-12	238	?	4	1	6
M-10	235	1	4	?	7
M- 9	221	?	3	1	6
M- 8	197	1	?	?	5
M- 7	179	?	3	4	9
M- 6	162	?	4	?	8
M- 5	139	1	0	1	?
M- 3	118	1	0	1	?
M- 1	98	5	3	3	11
TRIBUTARY STREAMS					
BIG SIOUX RIVER	BS-51	1	?	4	7
FLOYD RIVER	-	0	0	1	1
SOLDIER RIVER	S-45	0	9	?	11
BOYER RIVER	B-43	1	5	3	9
PLATTE RIVER	P-37	4	4	?	10
KANSAS RIVER	Kr-22	0	3	?	5
BLUE RIVER	-	0	0	0	0
GRAND RIVER	Gr-13	?	5	?	9
OSAGE RIVER	O-4	1	3	3	7
GASCONADE RIVER	G-2	1	4	1	6

NOTE: Bottom organism identifications are in Appendix Table No. B-16.

TABLE 7

SUMMARY OF TRIBUTARY STREAM DATA

MISSOURI RIVER

TRIBUTARY STREAM	Enters Missouri River at R.M.	5-Day Biochemical Oxygen Demand			Dissolved Oxygen			8-Day Normal		2-Day Wet		Winter		Total Suspended Solids		
		8-Day Normal	2-Day Wet	Winter	8-Day Normal	2-Day Wet	Winter	Total	Fecal	Total	Fecal	Total	Fecal	8-Day Normal	2-Day Wet	Winter
Big Sioux River(BS-51)	734.0	9.1	6.0	-	12.0	6.0	-	1,130	110	17,000	4,000	-	-	55	71	-
Soldier River(S-45)	664.0	2.3	6.9	-	9.9	6.6	-	14,700	4,000	2,400,000	2,000,000	-	-	10	3,530	-
Boyer River(B-43)	635.1	9.2	14.0	-	8.2	5.7	-	114,400	20,500	> 2,000,000	1,500,000	-	-	789	999	-
Papillion Creek(PA-37A)	596.5	-	177	84	-	-	3.9	-	-	16,000,000	11,000,000	4,040,000	591,200	-	-	100
Platte River(P-37)	594.8	7.9	8.2	2.1	9.2	7.3	10.0	27,700	11,200	620,000	290,000	36,000	18,700	763	-	39
Kansas River(KR-22)	367.4	3.1			9.6			116,000	6,800					284		
Grand River(GR-13)	250.0	3.3			9.3			4,000	< 460					59		
Chariton River(C-11)	238.8	3.4			10.4			> 10,700	2,340					54		
Osage River(O-4)	130.0	1.6			9.4			5,000	1,100					55		
Cascconde River(C-2)	104.4	3.2			9.7			2,600	570					66		

3/8

Offutt Air Force Base, and the community of Bellevue, Nebraska. This small creek was sampled during both the fall and winter surveys. Sampling was confined to three days, all of which were affected by rain, during the autumn survey. Water quality approached that of untreated sewage with a BOD_5 of 127 mg/l and a fecal coliform density of 11,000,000 MPN/100 ml. Water quality was only slightly better during the winter survey when the BOD_5 was 84 mg/l and the fecal coliform density was 591,000 MPN/100 ml.

Platte River

The Platte River is the largest tributary to the Missouri River in the reach from Gavins Point Dam to St. Joseph, Missouri. This stream was sampled for chemical and bacteriological analyses during both the autumn and winter surveys. Biological sampling was conducted during the autumn period only.

During the autumn and winter surveys, the fecal coliform densities were quite similar with densities of 11,200 MPN/100 ml and 18,700 MPN/100 ml, respectively. However, the densities increased to 290,000 MPN/100 ml during the 2-day, rain-affected period.

The average concentration of suspended solids during the winter survey was only four percent (32 mg/l) of that during the autumn survey (763 mg/l). The frozen condition of the watershed, and low runoff, accounted for this reduction.

The bottom animal community during the autumn survey was composed of predominately clean water forms. Four pollution sensitive and two pollution tolerant animal kinds were found.

Kansas River

Bottom materials from the Kansas River were composed primarily of paunch manure and organic sludges, and emanated a distinct rotten egg odor during the autumn survey. Bubbling gases from these bottom deposits, oil and floating solids such as, animal fat, clotted blood, and hair were observed in this stream. Only pollution tolerant sludgeworms, mothflies and midge larvae were found in the bottom animal community.

The fecal coliform bacterial density was 6,800 MPN/100 ml near the stream mouth. Total suspended solids averaged 284 mg/l.

Blue River

The Blue River was severely polluted by wastes discharged from the Kansas City Blue River sewage treatment plant, and industrial wastes including that from steel processing. Bottom samples collected from the Blue River were devoid of bottom animals which indicated gross

organic pollution and possibly, the presence of toxic materials. Bottom sediments were composed of a gray-black organic sludge that had a strong hydrogen sulfide odor. The water was colored gray and pockmarked by bubbles of decomposition gases.

Grand River

When sampled during the autumn survey, this stream had low flows averaging 167 cfs. (Winter flows averaged 5,500 cfs.) The bottom animal community was composed of two pollution sensitive, and two pollution tolerant forms. Two-thirds of the population density were tolerant sludgeworms. Mean fecal coliform densities were < 460 MPN/100 ml during this low flow period.

Chariton River

This stream had a mean flow of only 54 cfs during the autumn sampling period. Fecal coliform bacteria had a geometric mean of 2,340 MPN/100 ml which exceeded the NTAC contact and non-body contact recreation criteria. The average D.O. of 10.4 mg/l was near saturation and satisfactory for aquatic life.

Osage River

The Osage River is a large tributary to the lower Missouri River. The flow averaged 5,380 cfs during the autumn survey, and 21,000 cfs during the winter survey. During the autumn survey, fecal coliform bacteria had a geometric mean of 1,100 MPN/100 ml which exceeded the NTAC contact and non-body contact recreation criteria. The bottom organism community was composed of one pollution sensitive and three pollution tolerant forms. However, more than one-half the population density was composed of the pollution sensitive variety.

Gasconade River

Waters of this stream had geometric mean fecal coliform densities of 570 MPN/100 ml which exceeded the NTAC primary contact recreation standard of 200 MPN/100 ml. However, land runoff from the 1-2/3 inches of rain during the two-week autumn survey may have increased the densities. The bottom animal community was composed of one pollution sensitive and one pollution tolerant form. One-third of the population density was composed of tolerant sludgeworms.

MUNICIPAL WASTE SOURCES

Seven of the larger municipal waste discharges were sampled during the Missouri River surveys (Table 8). Six of the discharges were final effluents from primary waste treatment plants; one reported discharge was a composite of two separate Omaha sewers which discharged untreated wastes to the Missouri River: the Monroe Street and South Omaha interceptor sewers.

TABLE 8

MUNICIPAL WASTE SOURCES

MISSOURI RIVER

WASTE DISCHARGE	Sampling Period	FLOW MGD	BOD_5 mg/l	Total Suspend. Solids mg/l	BACTERIAL DENSITIES TOTAL COLI MPN/100ml	BACTERIAL DENSITIES FECAL COLI MPN/100ml	BACTERIAL DENSITIES FECAL STREP MF/100ml	Total(2) Organic Carbon mg/l	Total(2) Phos-Phorus mg/l	Total(2) Nitro-gen mg/l	Grease mg/l
Sioux City, Iowa STP	Oct. 7-18, 1968	16.2	247	109	75,200,000	20,200,000	-	97	10.6	78.8	17
	Jan.20-31, 1969	14.6	340	130	19,460,000	5,150,000	8,760,000	65	14.2	73.2	38
Omaha, Nebraska:											
Composite: Monroe St. & So. Omaha Sewers	Oct. 7-18, 1968	34.3	985	891	18,600,000	7,760,000	-	212	11.4	67.2	299
Missouri River Sewage Treatment Plant	Jan.20-24, 1969	16.0(3)	256	91	11,180,000	3,000,000	16,650,000	30	6.9	26.8	26
Council Bluffs, Iowa Sewage Treatment Plant	Oct. 1968(1)	5(3)	-	-	160,000,000	35,000,000	-	-	-	-	
	Jan.27-31, 1969	5.2	335	99	22,540,000	4,330,000	1,320,000	61	16.5	57.0	31
Kansas City, Missouri:											
Blue River Sewage Treatment Plant	Oct.28-Nov. 1, 1968	42.6	171	87	46,000,000	4,500,000	-	49	9.8	32.6	-
	Jan.20-24, 1969	59.0	136	78	40,440,000	7,930,000	7,880,000	31	8.7	30.4	-
West Side Sewage Treatment Plant	Jan.27-31, 1969	17.3	123	58	8,940,000	2,760,000	5,050,000	28	5.6	24.4	-
Kansas City, Kansas: Sewage Treatment Plant	Nov. 4-8, 1968	7.8	277	267	46,000,000	9,700,000	-	82	12.0	43.7	-

NOTES: (1) Single grab sample.

(2) Weekly composite made from 5 daily composite samples.

(3) Estimated by plant personnel.

Secondary treatment of these discharges as well as other smaller municipal treatment plants, and industrial waste discharges would substantially reduce concentrations of BOD; total organic carbon; settleable and suspended solids; grease and other floatable materials; and bacteria and viruses discharged to the Missouri River from these controllable sources. Resulting water quality improvement in the Missouri River would be both aesthetic through removal of obnoxiously appearing suspended and floatable material which forms scum on pile dikes and settles to form sludge in backwater areas; and bacteriologically by affording a safer water for recreation and for municipal water supply.

Future water quality studies will be designed to quantitate these and additional water quality improvements.

APPENDIX A

STATION DESCRIPTIONS
(by Missouri River Mile)

MISSOURI RIVER BASIN SURVEYS

STATION	River Mile[1]	Sample Type[2]	DESCRIPTION
M-1	98.0	A	Missouri River at State Highway 19 bridge, Hermann, Missouri.
G-2	104.4	A	Gasconade River at State Highway 100 - 1 mile upstream from confluence.
M-3	118.0	A	Missouri River at Chamois, Missouri (0.2 miles upstream from Kishmar Light).
O-4	130.0	A	Osage River at Bonnots Mill Landing, Missouri.
M-5A	132.0	C	Missouri River at small boat dock - off Missouri State Highway 94.
M-5	139.0	A	Missouri River - 3 miles downstream from Jefferson City, Missouri (at Moreau River light).
M-6	162.0	A	Missouri River at Wilton, Missouri (0.2 miles upstream from Wilton light).
M-7A	174.8	C	Missouri River at Lupus, Missouri.
M-7	179.0	A	Missouri River at Searcys Bend - 4 miles upstream from Lupus, Missouri (at Searcys Bend light).

(1) Biology stations may not coincide exactly with chemical and bacteriological sampling stations; usually they were ± 0.2 mile.

(2) Sample type: A - Chemical, bacteriological and biology sample station.
B - Biology sample station only.
C - Chemical and bacteriological sampling station only.

APPENDIX A
(contd)

STATION DESCRIPTIONS
(by Missouri River Mile)

MISSOURI RIVER BASIN SURVEYS

STATION	River Mile[1]	Sample Type[2]	DESCRIPTION
M-8	197.2	A	Missouri River at M.K.T. RR bridge, Boonville, Missouri.
M-9A	219.2	C	Missouri River at limestone quarry, downstream from Bluffport, Missouri.
M-9	221.0	A	Missouri River at Fish Creek Bend - 5 miles downstream from Glasgow, Missouri (at Brockway Island Light - 221.0).
M-10	235.1	A	Missouri River at Gilliam Bend - 6 miles downstream from New Frankfort, Missouri (at light).
C-11	238.8	A	Chariton River upstream from confluence. For October 28-30 at a point approximately 1 mile upstream. For October 31-November 8 at Price Bridge, Highway VV south of Keytesville, Missouri.
M-12	241.2	A	Missouri River at New Frankfort Landing, Missouri.
GR-13	250.0	A	Grand River upstream from confluence. For October 28-30 at Brunswick. For October 31-November 8 at U.S. Highway 24 Bridge, Missouri.
M-14	270.0	A	Missouri River at Ray-Carrol County, Grain Growers, Inc., loading dock, east of Wakenda, Missouri.

APPENDIX A
(contd)

STATION DESCRIPTIONS
(by Missouri River Mile)

MISSOURI RIVER BASIN SURVEYS

STATION	River Mile[1]	Sample Type[2]	DESCRIPTION
M-15	293.4	A	Missouri River at U. S. Highway 24 & 65 - Waverly, Missouri.
M-16	313.2	A	Missouri River - 4 miles downstream from Lexington, Missouri (at Ray-Carrol G.G., Inc. loading dock).
M-17	334.5	A	Missouri River at Fishing River Landing via gravel road south from Orrick, Missouri.
M-18	345.4	A	Missouri River at N. W. Electric (Co-operative) Power Plant near Missouri City, Missouri.
-	356 ±	B	Missouri River downstream from confluence with Blue River.
K-19	358.0	C	Kansas City Blue River Sewage Treatment Plant (effluent to Big Blue River).
-	358.0	B	Big Blue River.
M-20A	358.3	C	Missouri River at Kansas City Power and Light Company - Hawthorne Plant water intake structure.
M-20	359.3	A	Missouri River at C.R.I. & P. RR bridge.
M-21	365.6	A	Missouri River A.S.B. Highway & RR bridge.
K-19B	367.19	C	Kansas City, Missouri West Side Sewage Treatment Plant effluent.
K-19A	367.20	C	Kansas City, Kansas Sewage Treatment Plant effluent.

APPENDIX A
(contd)

STATION DESCRIPTIONS
(by Missouri River Mile)

MISSOURI RIVER BASIN SURVEYS

STATION	River Mile[1]	Sample Type[2]	DESCRIPTION
KR-22	367.4	A	Kansas River at Central Avenue bridge.
M-23	370.5	A	Missouri River at Kansas City, Missouri Waterworks Intake opposite Fairfax Airport.
M-24	384.9	A	Missouri River upstream from Kansas City (at Weavers light).
M-25	397.4	A	Missouri River at Leavenworth, Kansas (0.2 miles downstream from Highway bridge).
M-25.5	418.0	C	Missouri River - approximately 4 miles downstream from Atchison, Kansas.
M-26A	422.5	C	Missouri River at Atchison and Eastern Railroad Company bridge.
M-26	422.6	A	Missouri River at Atchison, Kansas (0.1 miles upstream from RR bridge).
M-27	440.3	A	Missouri River at Palermo landing (1.3 miles upstream from Palermo light).
M-28	452.3	A	Missouri River at St. Joseph Water Company Waterworks Intake.
M-29	469.0	A	Missouri River - 0.5 miles upstream from Charleston landing (Daymark).
M-30	488.3	A	Missouri River at White Cloud, Kansas (at power cable crossing).
M-31	507.5	A	Missouri River - 9.5 miles upstream from Rulo, Nebraska.

APPENDIX A
(contd)

STATION DESCRIPTIONS
(by Missouri River Mile)

MISSOURI RIVER BASIN SURVEYS

STATION	River Mile[1]	Sample Type[2]	DESCRIPTION
M-32	525.1	A	Missouri River (at Upper Morgan Bend, upper light).
M-33	546.7	A	Missouri River at Peru Sportsman Club ramp.
M-34	559.7	A	Missouri River downstream from Nebraska City (0.2 miles upstream from Frazers light).
M-35	580.9	A	Missouri River at Bartlett, Iowa (at Shenandoah Boat Club ramp).
M-36	591.2	A	Missouri River at Plattsmouth, Nebraska (0.2 miles downstream from Pollock light).
P-37	594.8	A	Platte River at U.S. Highway 75 bridge, Nebraska.
PA-37A	596.5	C	Big Papillion Creek at Offutt Air Force Base Road to Capehart, Nebraska - off U.S. Highway 75.
M-38	601.3	A	Missouri River at Bellevue, Nebraska (0.1 miles downstream from State Highway 370 bridge).
M-39	610.5	A	Missouri River downstream from Omaha STP outfall (at power cable crossing).
OM-40	611.5	C	Composite sample of 7 parts Monroe St. Sewer effluent and 1 part South Omaha Sewer, Omaha, Nebraska (approximate river mileage).
OM-40A	611.5	C	Omaha, Missouri River Sewage Treatment Plant effluent (approximate river mileage).

APPENDIX A
(contd)

STATION DESCRIPTIONS
(by Missouri River Mile)

MISSOURI RIVER BASIN SURVEYS

STATION	River Mile[1]	Sample Type[2]	DESCRIPTION
CB-40B	614.0	C	Council Bluffs Sewage Treatment Plant effluent (approximate river mileage).
M-41	618.3	A	Missouri River at I.C. RR bridge.
M-42	626.2	A	Missouri River at Omaha Waterworks Intake (0.3 miles downstream from Highway 36 bridge).
B-43	635.1	A	Boyer River at I-29 Highway bridge, Iowa.
M-44	654.6	A	Missouri River upstream from Blair, Nebraska (at Tyson Boat Marina).
S-45	664.0	A	Soldier River at I-29 Highway bridge, Iowa.
M-46	676.5	A	Missouri River at Upper Sioux Reach, upper light.
M-47	699.5	A	Missouri River at Lighthouse Marina (also called Don Ruth Marina - 6 miles from Whiting, Iowa).
M-48	717.4	A	Missouri River downstream from Sioux City STP outfall (at power cable crossing).
M-48A	718.3	C	Iowa Power and Light Co. Power Plant.
SC-49	729.0	C	Sioux City Sewage Treatment Plant effluent (approximate river mileage).
M-50	730.0	A	Missouri River downstream from Floyd River confluence - Sioux City, Iowa (at power cable crossing).
-	731	B	Floyd River 0.1 miles upstream from the confluence.

APPENDIX A
(contd)

STATION DESCRIPTIONS
(by Missouri River Mile)

MISSOURI RIVER BASIN SURVEYS

STATION	River Mile[1]	Sample Type[2]	DESCRIPTION
M-52A	732.8	C	Missouri River 0.5 miles upstream from U.S. 73 Highway bridge.
BS-51	734.0	A	Big Sioux River upstream from confluence (at I-29 Highway bridge).
M-52	736.0	A	Missouri River - 2 miles upstream from Sioux River confluence.
Gavins Pt. Dam	811.0	C	Lewis and Clark Reservoir Dam upstream from Yankton, South Dakota (Corps of Engineers).

APPENDIX B

DATA SUMMARY

TABLE NO. B-1

Summary of 8- & 2-Day Averages[1] for Discrete Samples
MISSOURI RIVER
OCTOBER 7-18, 1968 SURVEY

STATION Name	River Mileage	TEMPERATURE °C 8-Day	TEMPERATURE °C 2-Day	DISSOLVED OXYGEN mg/l 8-Day	DISSOLVED OXYGEN mg/l 2-Day	2-DAY BOD mg/l 8-Day	2-DAY BOD mg/l 2-Day	5-DAY BOD mg/l 8-Day	5-DAY BOD mg/l 2-Day	pH Units 8-Day	pH Units 2-Day	ALKALINITY $CaCO_3$ mg/l 8-Day	ALKALINITY $CaCO_3$ mg/l 2-Day	HARDNESS $CaCO_3$ mg/l 8-Day	HARDNESS $CaCO_3$ mg/l 2-Day
MISSOURI RIVER:															
Gavins Pt. Dam	811.0	-	-	-	-	-	-	-	-	8.3[2]	-	169[2]	-	238[2]	-
M-52	736.0	14	10	9.5	10.0	0.4	0.6	0.9	1.2	8.3	8.4	166	160	252	254
M-50	730.0	14	10	9.4	9.7	0.4	0.6	1.1	1.2	8.3	8.3	165	160	249	275
M-48	717.4	14	11	9.3	9.4	0.8	0.8	1.5	1.6	8.3	8.3	167	160	252	258
M-47	699.5	15	12	9.2	9.2	0.8	0.9	1.6	1.8	8.3	8.3	174	154	257	254
M-46	676.5	15	11	9.2	9.0	0.7	1.0	1.4	1.8	8.3	8.3	160	158	254	258
M-44	654.6	15	13	9.1	8.0	0.8	1.9	1.5	4.0	8.3	8.2	197	156	264	254
M-42	626.2	14	12	9.1	8.0	1.1	2.6	1.9	4.9	8.2	8.2	172	168	237	271
M-41	618.3	14	14	8.9	7.8	1.2	2.2	2.0	4.2	8.2	8.2	169	154	263	238
M-39	610.5	14	13	8.8	-	3.6	3.2	5.8	6.1	8.3	8.1	164	114	254	238
M-38	601.3	15	13	8.8	7.6	1.9	2.6	3.4	5.2	8.6	8.1	168	147	250	238
M-36	591.2	15	12	8.6	7.8	1.9	2.9	3.4	5.4	8.2	8.1	167	154	249	242
M-35	580.9	15	12	8.6	7.5	1.8	2.9	3.3	5.6	8.1	8.0	168	180	272	258
M-34	559.7	14	14	8.5	6.8	1.3	3.3	2.8	6.8	8.3	8.0	169	148	262	226
M-33	546.7	15	14	8.4	7.0	1.7	3.9	3.2	6.7	8.3	8.0	170	146	256	246
M-32	525.1	15	14	8.6	6.1	1.3	2.8	2.6	7.0	8.2	8.0	174	158	258	246
M-31	507.5	15	14	8.6	6.6	1.3	2.5	2.6	5.8	8.2	8.0	165	160	253	258
M-30	488.3	15	15	8.3	6.0	1.9	2.6	3.2	5.8	8.2	7.8	170	152	258	258
M-29	469.0	15	15	8.6	5.2	2.1	3.0	3.4	7.6	8.2	7.8	173	145	261	242
M-28	452.3	16	16	8.6	5.6	1.8	-	3.0	-	8.3	8.0	163	158	254	246
M-27	440.3	16	15	8.7	5.6	1.6	2.9	3.0	5.6	8.2	7.8	171	143	263	242
TRIBUTARIES:[5]															
BS-51	734.0	14	11	12.0	6.0	4.6	3.4	9.1	6.0	8.4	8.0	214	177	388	385
S-45[3]	664.0	-	10	9.9	6.6	1.3	5.2	2.3	6.9	8.3	7.8	255	149	350	246
B-43	635.1	14	10	8.2	5.7	5.0	8.1	9.2	14.0	8.1	7.8	251	174	340	242
PA-37A[4]	596.5	-	10	-	-	-	55	-	127	-	-	-	-	-	-
P-37	594.8	16	11	9.2	7.8	4.2	3.8	7.9	8.2	8.2	7.7	158	130	199	184
WASTE SOURCES:[5]															
SC-49	729.0	-	-	-	-	152	160	247	260	7.4	8.0	412	374	439	344
OM-40[3]	611.5	-	-	-	-	554	551	985	847	7.3	7.7	249	225	263	293
CB-40B	614	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE NO. B-1
(contd)

Summary of 8- & 2-Day Averages[1] for Discrete Samples
MISSOURI RIVER
OCTOBER 7-18, 1968 SURVEY

STATION Name	River Mileage	TURBIDITY Units 8-Day	TURBIDITY Units 2-Day	TOTAL SUSP. SOLIDS mg/l 8-Day	TOTAL SUSP. SOLIDS mg/l 2-Day	TOTAL DISSOL. SOLIDS mg/l 8-Day	TOTAL DISSOL. SOLIDS mg/l 2-Day	SPEC. CONDUC. µmhos/cm at 25°C. 8-Day	SPEC. CONDUC. µmhos/cm at 25°C. 2-Day	CHLORIDE mg/l 8-Day	CHLORIDE mg/l 2-Day	SULFATE mg/l 8-Day	SULFATE mg/l 2-Day
MISSOURI RIVER:													
Gavins Pt. Dam	811.0	14[2]	-	45[2]	-	474[2]	-	800[2]	-	12[2]	-	208[2]	-
M-52	736.0	22	30	55	-	471	-	800	750	11	13	203	212
M-50	730.0	21	34	62	87	484	497	820	380	12	14	214	245
M-48	717.4	24	48	44	147	494	365	790	720	12	14	209	188
M-47	699.5	24	46	61	114	552	341	800	730	11	15	191	245
M-46	676.5	24	39	58	102	496	398	790	740	12	13	210	212
M-44	654.6	44	255	155	715	533	287	790	720	12	19	199	188
M-42	626.2	36	231	91	1020	532	330	800	680	13	13	185	182
M-41	618.3	47	245	120	740	540	326	790	710	12	17	180	158
M-39	610.5	39	250	95	850	478	469	790	680	13	17	216	172
M-38	601.3	37	350	95	998	493	313	790	770	16	17	210	170
M-36	591.2	46	300	136	1100	485	327	790	770	15	18	187	198
M-35	580.9	50	325	185	1340	490	-	790	640	15	18	172	330
M-34	559.7	67	470	220	1610	493	500	790	640	19	27	164	185
M-33	546.7	114	440	238	1780	482	-	780	650	17	27	187	180
M-32	525.1	59	492	278	1120	645	245	780	660	20	32	220	128
M-31	507.5	64	560	142	1310	480	516	800	640	18	28	209	-
M-30	488.3	52	810	110	1480	512	449	700	600	22	16	194	162
M-29	469.0	46	985	123	2550	468	312	790	580	21	21	166	145
M-28	452.3	48	1120	131	2780	472	198	780	600	17	20	170	165
M-27	440.3	47	1120	142	2890	458	174	780	600	17	21	186	130
TRIBUTARIES:[5]													
BS-51	734.0	20	30	55	71	547	422	1040	900	45	52	169	142
S-45[3]	664.0	6	1670	10	3530	423	3670	660	340	13	13	40	26
B-43	635.1	245	1850	729	999	392	2860	700	400	45	22	78	37
PA-37A[4]	596.5	-	-	-	-	-	-	-	-	-	-	-	-
P-37	594.8	175	538	763	-	504	-	810	670	69	69	68	77
WASTE SOURCES:[5]													
SC-49	729.0	61	94	109	170	1330	1020	2230	1900	243	300	236	140
OM-40[3]	611.5	178	297	891	840	1650	1690	2370	2110	481	499	234	188
CB-40B	614	-	-	-	-	-	-	-	-	-	-	-	-

1/ 8-day average is for typical Fall weather, where total precipitation was 0.46" in Omaha;
2-day average is for extremely wet weather, where precipitation was 3.61.
2/ Average of two 5-day composite samples (Gavins Pt. Dam only).
3/ Averages for 7 days of typical Fall and 3 days of extremely wet weather.
4/ Average for 3 days of extremely wet weather.
5/ River Mileage refers to point where tributary or waste source enters Missouri River.
Samples were collected on tributary or waste source upstream from confluence.

TABLE NO. B-2

Summary of Averages for Discrete Samples
MISSOURI RIVER
OCTOBER 28-NOVEMBER 8, 1968 SURVEY

STATION Name	River Mileage	TEMPERATURE °C	DISSOLVED OXYGEN mg/l	2-DAY BOD mg/l	5-DAY BOD mg/l	pH Units	ALKALINITY as $CaCO_3$ mg/l	HARDNESS as $CaCO_3$ mg/l
MISSOURI RIVER:								
M-27	440.3	9	9.8	1.5	3.0	8.2	179	257
M-26[1]	422.6	10	9.7	1.4	2.6	8.2	181	248
M-25.5[2]	418.0	9	9.6	1.6	3.2	8.2	179	263
M-25	397.4	9	9.5	1.4	3.0	8.2	179	248
M-24	384.9	10	9.6	1.5	3.0	8.3	186	258
M-23	370.5	9	9.7	1.5	2.9	8.2	179	261
M-21	365.6	10	9.6	1.7	3.5	8.2	180	243
M-20	359.3	10	9.7	1.4	2.7	8.2	181	242
M-18	345.4	10	9.4	1.4	3.0	8.2	180	243
M-17	334.5	10	9.4	1.5	2.7	8.2	181	242
M-16	313.2	10	9.2	1.3	2.8	8.2	181	246
M-15	293.4	10	9.3	1.3	2.6	8.2	180	244
M-14	270.0	10	9.4	1.0	2.2	8.2	176	244
M-12	241.2	10	9.5	0.9	2.1	8.2	177	237
M-10	235.1	10	9.5	1.0	1.8	8.2	174	239
M- 9	221.0	10	9.6	0.9	1.7	8.2	174	241
M- 8	197.2	10	9.5	1.3	2.4	8.1	174	242
M- 7	179.0	10	9.5	1.4	2.4	8.2	174	250
M- 6	162.0	10	9.6	1.2	2.4	8.2	174	254
M- 5	139.0	10	9.6	1.2	2.4	8.2	174	239
M- 3	118.0	12	9.7	2.4	4.1	8.2	161	208
M- 1	98.0	12	9.8	1.9	3.5	8.1	162	210
TRIBUTARIES:[3]								
KR-22	367.4	11	9.6	1.6	3.1	8.2	182	213
GR-13	250.0	11	9.3	1.9	3.3	8.1	182	193
C-11	238.8	9	10.4	1.8	3.4	8.2	168	196
O-4	130.0	13	9.4	1.0	1.6	8.1	112	154
G-2	104.4	12	9.7	2.0	3.2	8.2	167	179
WASTE SOURCES:[3]								
K-12[2]	367.20	19	-	147	277	7.6	301	292
K-19[2]	356.9	-	-	127	171	7.2	188	229

TABLE NO. B-2
(contd)

Summary of Averages for Discrete Samples
MISSOURI RIVER
OCTOBER 28-NOVEMBER 8, 1968 SURVEY

STATION Name	River Mileage	TURBIDITY Units	TOTAL SUSP. SOLIDS mg/l	TOTAL DISSOL.SOLIDS mg/l	SPEC. CONDUC. µmhos/cm at 25°C.	CHLORIDE mg/l	SULFATE mg/l
MISSOURI RIVER:							
M-27	440.3	55	161	485	[illegible]C	17	174
M-26 1/	422.6	61	200	490	71[illegible]	16	203
M-25.5 2/	418.0	53	141	496	720	16	192
M-25	397.4	58	165	494	710	16	194
M-24	384.9	60	165	504	[illegible]C	16	201
M-23	370.5	61	173	497	[illegible]10	17	198
M-21	369.6	102	202	464	670	20	176
M-20	359.3	86	204	468	680	18	190
M-18	349.4	99	194	471	680	19	190
M-17	336.5	100	188	469	680	18	186
M-16	313.2	101	214	459	680	19	179
M-15	293.4	103	213	452	670	18	188
M-14	270.0	71	229	466	680	19	154
M-12	241.2	74	227	466	680	19	156
M-10	239.1	73	238	445	670	19	153
M- 9	221.0	72	215	458	690	19	154
M- 8	197.2	75	276	448	680	19	152
M- 7	179.0	79	257	446	680	19	150
M- 6	162.0	81	297	434	670	19	152
M- 5	139.0	81	265	449	660	19	152
M- 3	118.0	68	250	373	580	17	122
M- 1	98.0	78	241	375	570	16	113
TRIBUTARIES: 3/							
KR-22	367.4	135	284	312	500	29	103
GR-13	250.0	31	59	266	450	12	41
C-11	238.8	36	54	285	470	10	63
O- 4	130.0	28	55	174	290	5	22
O- 2	104.4	34	66	194	330	4	5
WASTE SOURCES: 3/							
K-19 2/	367.20	87	265	741	1260	123	241
K-19 1/	396.9	64	87	656	980	85	229

1/ Result for 5 discrete samples, 10/28 - 11/1/68.
2/ Result for 5 discrete samples, 11/4 - 11/8/68.
3/ River Mileage refers to point where tributary or waste source enters Missouri River. Samples were collected on tributary or waste source upstream from confluence.

TABLE NO. B-3

Summary of Averages for Discrete Samples
MISSOURI RIVER
January 20-February 2, 1969

STATION Name	River Mileage	TEMPERATURE °C	DISSOLVED OXYGEN mg/l	2-DAY BOD mg/l	5-DAY BOD mg/l	pH Units	ALKALINITY Ca CO_3 mg/l
MISSOURI RIVER:							
Gavins Pt. Dam[1]	811.0	-	-	-	-	-	-
M-52A	732.8	0	12.7	0.4	1.1	8.1	175
M-48A	718.3	0	12 6	0.8	1.6	8.1	174
M-47	699.5	0	12.7	1.0	2.0	8.1	176
M-42	626.2	0	13.2	0.8	1.4	8.1	192
M-38	601.3	0	12.8	2.2	3.6	8.1	187
M-35	580.9	0	12.5	1.7	2.7	8.0	188
M-34	559.7	0	10.6	1.1	1.9	8.0	185
M-32	525.1	0	9.4	1.1	2.2	7 9	182
M-30[2]	488.3	2	9.1	1.7	3.4	7.8	165
M-28	452.3	2	9.6	1.5	3.0	7.8	174
M-27	440.3	2	10.0	1.3	2.9	7.8	175
M-26A	422.5	2	10.3	1.6	3.5	7.8	176
M-23	370.5	0	11.0	2.2	4.0	8.0	174
M-20A	358.3	0	11.2	2.7	5.1	7.9	181
M-18	345.4	0	11.3	2.1	4.3	7.9	183
M-17	334.5	0	11.2	3.1	5.4	7.9	183
M-15	293.4	0	11.2	2.7	5.3	7.9	186
M-14	270.0	0	11.3	2.5	5.1	7.9	179
M-12	241.2	0	11.2	2.8	5.0	7.8	178
M-9A	219.2	0	10.7	3.2	> 5.5	7.7	144
M-7A	174.8	0	11.0	3.0	> 5.6	7.6	132
M-5A	132.0	0	10.7	7.7	> 10.9	7.6	136
M-1	98.0	1	11.8	2.3	4.3	7.7	116
TRIBUTARIES:[3]							
PA-37A	596.5	1	3.9	41	84	7.8	289
P-37	594.8	0	10.0	1.1	2.1	7.9	181
WASTE SOURCES:[3]							
SC-49[4]	729.0	17	-	207	340	7.6	472
CB-40B[2]	614	-	-	172	335	7.3	213
OM-40A[4]	611.5	-	-	162	256	7.9	208
K-19B[4]	367.19	-	-	71	123	7.4	158
K-19[2]	356.9	-	-	88	136	7.4	206

TABLE NO. B-3
(contd)

Summary of Averages for Discrete Samples
MISSOURI RIVER
January 20-February 2, 1969

STATION Name	River Mileage	TURBIDITY Units	TOTAL SUSP. SOLIDS mg/l	TOTAL DISSOL. SOLIDS mg/l	SPEC. CONDUC. µmhos/cm at 25°C.	CHLORIDE mg/l	SULFATE mg/l
MISSOURI RIVER:							
Gavins Pt. Dam[1]	811.0	1.5	1.5	518	-	11	206
M-52A	732.8	19	48	546	800	12	214
M-48A	718.3	10	23	553	810	13	213
M-47	699.5	9	18	554	8[illegible]	14	213
M-42	626.2	9	25	629	86[illegible]	15	224
M-38	601.3	8	17	570	81[illegible]	16	221
M-35	580.9	8	17	653	7[illegible]	18	206
M-34	559.7	7	12	525	76[illegible]	25	175
M-32[2]	525.1	6	9	527	7[illegible]	22	173
M-30[2]	488.3	17	27	486	710	22	170
M-28	452.3	12	26	510	740	23	177
M-27	440.3	12	29	517	73[illegible]	23	179
M-26A	422.5	16	42	506	74[illegible]	23	175
M-23	370.5	29	73	485	7[illegible]	22	185
M-20A	358.3	35	91	489	7[illegible]	25	178
M-18	345.4	41	115	491	7[illegible]	26	168
M-17	334.5	44	102	494	730	27	173
M-15	293.4	60	141	496	7[illegible]	27	181
M-14	270.0	70	233	480	710	28	173
M-12	241.2	66	197	489	680	26	150
M-9A	219.2	144	423	403	560	20	120
M-7A	174.8	211	596	337	480	17	95
M-5A	132.0	219	543	371	5[illegible]0	19	109
M-1	98.0	138	331	254	360	9	55
TRIBUTARIES:[3]							
PA-37A	596.5	41	100	646	1000	106	80
P-37	594.8	16	32	455	700	56	81
WASTE SOURCES:[3]							
SC-49[4]	729.0	55	130	1482	[illegible]770	334	200
CB-40B[2]	614	55	99	908	1370	113	242
OM-40A[4]	611.5	52	91	1132	1650	291	238
K-19B[4]	367.19	40	58	1428	[illegible]290	538	232
K-19[2]	356.9	50	78	836	1230	145	217

1/ Result for the average of two 5-day composite samples.
2/ Result for five discrete samples, 1/20 - 1/24/69.
3/ River Mileage refers to point where tributary or waste source enters Missouri River.
Samples were collected on tributary or waste source upstream from confluence.
4/ Result for five discrete samples, 1/27 - 1/31/69.

TABLE NO. B-4

Summary of Bacterial Densities

MISSOURI RIVER
October 7-18, 1968 Survey

STATION Name	River Mileage	Time-of-Water[5] Travel Hours	TOTAL COLIFORM BACTERIA MPN/100 ml Normal 8-Day Mean	Upper 80% Conf. Limit	Lower 80% Conf. Limit	Wet 2-Day Mean	FECAL COLIFORM BACTERIA MPN/100 ml Normal 8-Day Mean	Upper 80% Conf. Limit	Lower 80% Conf. Limit	Wet 2-Day Mean	FECAL COLIFORM BACTERIA as a % of TOTAL COLIFORM BACTERIA Normal 8-Day	Wet 2-Day
MISSOURI RIVER:												
Gavins Pt. Dam	811.0	-	950[1]	-	-	-	< 175[1]	-	-	-	< 50.0	-
M-52	736.0	- 1.6	1,380	3,940	490	74,800	220	710	70	30,500	15.9	40.5
M-50	730.0	0.5	2,420	6,050	970	74,800	340	1,000	60	47,000	9.9	62.8
M-48	717.4	5.2	62,800	204,400	17,600	265,000	14,300	48,900	4,210	116,000	22.8	43.8
M-47	699.5	11.3	57,100	197,800	16,500	230,300	26,600	129,500	6,460	108,000	46.6	47.0
M-46	676.5	18.8	53,000	178,000	15,800	213,000	18,900	77,900	4,590	149,000	35.7	70.0
M-44	654.6	25.2	39,500	91,400	17,100	852,000	9,030	50,600	1,610	278,000	22.9	32.6
M-42	636.2	34.7	58,300	198,900	14,200	424,000	8,390	34,100	2,030	207,000	15.9	50.0
M-41	618.3	37.3	46,600	293,100	9,750	802,000	11,200	34,600	3,630	207,000	24.0	25.8
M-39	610.5	39.3	256,400	708,000	92,800	330,000	61,200	164,600	22,800	230,000	23.9	69.7
M-38	601.3	41.6	165,200	421,800	64,700	460,000	45,200	96,400	21,200	330,000	27.4	71.7
M-36	591.2	44.2	174,200	306,200	99,100	790,000	53,500	107,600	26,600	490,000	30.7	62.0
M-35	580.9	47.3	130,400	495,600	34,300	790,000	38,480	104,130	14,200	330,000	29.4	41.8
M-34	559.7	53.8	166,600	474,400	58,600	1,440,000	50,800	150,000	17,700	1,180,000	30.4	77.8
M-33	546.7	57.7	189,400	377,600	94,900	> 777,000	58,500	85,400	18,000	460,000	30.3	< 63.3
M-32	525.1	64.7	100,400	232,900	43,300	767,000	19,000	50,400	7,130	358,000	18.9	45.9
M-31	507.5	70.6	133,800	894,500	60,800	838,000	26,000	70,900	11,800	435,000	21.0	51.9
M-30	488.3	77.1	154,400	614,000	38,800	-	28,400	128,100	6,310	-	18.4	-
M-29	469.0	83.9	247,800	398,700	55,600	-	14,600	73,400	3,900	-	9.9	-
M-28	458.3	89.8	57,700	258,900	13,700	855,000	6,480	26,900	1,560	935,000	11.7	77.2
M-27	440.3	93.6	65,300	168,900	25,300	790,000	11,800	26,300	5,130	330,000	18.1	41.8
TRIBUTARIES:												
BB-51	734.0	- 0.8	1,130	6,730	190	17,000	110	440	30	4,000	9.7	23.5
B-45	664.0	22.5	14,700	96,100	2,250	2,400,000	4,000	63,100	940	2,000,000	27.2	83.3
B-43	635.1	31.6	114,400	1,011,000	12,900	> 2,000,000	30,500	376,700	1,120	1,500,000	27.9	< 75.0
PA-37A	596.5	43.0	-	-	-	16,000,000[2]	-	-	-	11,000,000[2]	-	68.8
P-37	594.8	43.3	27,700	259,800	2,990	680,000	11,200	82,700	1,500	990,000	40.4	46.8
WASTE SOURCES:[4]												
SC-49	789.0	0.7	75,200,000	151,500,000	37,300,000	49,000,000	20,200,000	53,300,000	7,680,000	49,000,000	26.9	100.0
CB-40B	614.0	38.4	160,000,000[3]	-	-	-	35,000,000[3]	-	-	-	21.9	-
CM-40	611.5	39.1	18,600,000	42,500,000	8,160,000	30,000,000	7,760,000	19,400,000	3,100,000	11,000,000	41.7	36.7

1/ Average of two discrete samples.
2/ Average for 3 samples which were influenced by extremely wet weather.
3/ Single sample during normal weather period.
4/ River Mileage refers to point where tributary or waste source enters Missouri River. Samples were collected on tributary or waste source upstream from confluence.
5/ Time-of-water travel from USGS Gage at Sioux City, Iowa.

TABLE NO. B-5

Summary of Bacterial Densities

MISSOURI RIVER
October 28-November 8, 1968 Survey

STATION Name	River Mileage	Time-of-Water Travel Hours	TOTAL COLIFORM BACTERIA MPN/100 ml Geom. Mean	Upper 80% Conf.Limit	Lower 80% Conf.Limit	FECAL COLIFORM BACTERIA MPN/100 ml Geom. Mean	Upper 80% Conf.Limit	Lower 80% Conf.Limit	Fecal Coliform Bacteria as a % of Total Coliform Bacteria
MISSOURI RIVER:									
M-27	440.3	2.3	67,000	183,400	24,700	8,100	19,400	3,390	12.1
M-26 1/	422.6	7.7	37,000	51,900	27,000	11,000	18,400	6,270	29.7
M-25.5 2/	418.0	9.3	65,000	185,900	33,600	7,300	21,400	2,510	11.2
M-25	397.4	16.3	82,000	164,000	41,100	11,000	25,100	4,440	13.4
M-24	384.9	20.4	64,000	120,200	33,300	7,500	13,500	4,220	11.7
M-23	370.5	25.2	77,000	208,300	28,500	6,500	12,900	2,300	8.4
M-21	365.6	26.6	88,000	151,000	51,300	14,000	33,300	5,780	15.9
M-20	359.3	28.8	79,000	169,800	36,900	19,000	74,200	4,760	24.0
M-18	345.4	33.5	189,000	537,300	66,700	15,000	33,200	7,220	7.9
M-17	334.5	37.3	150,000	388,700	57,200	18,000	29,500	10,600	12.0
M-16	313.2	44.7	119,000	412,100	34,200	18,000	35,800	9,170	15.1
M-15	293.4	51.6	77,000	173,600	34,100	10,000	24,400	4,280	13.0
M-14	270.0	60.2	119,000	221,900	64,200	15,000	55,100	4,200	12.6
M-12	241.2	71.1	88,000	140,900	54,600	10,000	25,400	4,260	11.4
M-10	235.1	73.5	67,000	149,600	30,000	12,000	26,000	5,570	17.9
M- 9	221.0	78.7	80,000	206,300	31,200	8,900	29,200	2,700	11.1
M- 8	177.2	88.1	65,000	106,700	39,800	7,000	12,800	3,800	10.8
M- 7	179.0	90.4	39,000	72,800	20,700	5,700	23,900	1,350	14.6
M- 6	162.0	100.4	44,000	104,900	18,200	5,000	12,400	2,000	11.4
M- 5	139.0	108.5	41,000	87,500	19,500	5,400	12,700	2,300	13.2
M- 3	118.0	116.4	36,000	64,400	20,400	4,700	13,700	1,550	13.1
M- 1	98.0	124.7	15,000	35,000	6,100	3,800	9,250	1,570	25.3
TRIBUTARIES: 3/									
K-22	367.4	26.2	110,000	315,900	42,900	6,800	18,600	3,700	6.2
K-13	250.0	67.8	4,000	36,900	430	< 460	< 6,470	< 30	< 11.5
K-11	238.8	71.9	> 10,700	> 110,600	> 1,030	2,340	22,400	240	< 21.9
K- 4	130.0	112.1	5,000	61,300	410	1,100	14,500	80	22.0
K- 2	104.4	121.5	2,600	39,300	170	570	10,700	30	21.9
WASTE SOURCES: 3/									
K-14	367.2	26.2	46,000,000	88,200,000	24,400,000	9,700,000	21,300,000	4,390,000	21.1
K-19	356.9	29.6	46,000,000	59,000,000	36,100,000	4,500,000	7,360,000	2,810,000	9.8

1/ Results for five discrete samples, 10/28 - 11/1/68.
2/ Results for five discrete samples, 11/4 - 11/8/68.
3/ River Mileage refers to point where tributary or waste source enters the Missouri River. Samples were collected on tributary or waste source upstream from confluence.
4/ Time-of-water travel from USGS Gage at St. Joseph, Missouri.

TABLE NO. B-6

Summary of Bacterial Densities

MISSOURI RIVER
January 30-February 2, 1969 Survey

STATION Name	River Mileage	TOTAL COLIFORM BACTERIA MPN/100 ml Geom. Mean	Upper 80% Conf.Limit	Lower 80% Conf.Limit	FECAL COLIFORM BACTERIA MPN/100 ml Geom. Mean	Upper 80% Conf.Limit	Lower 80% Conf.Limit	FECAL STREPTOCOCCI BACTERIA MPN/100 ml Geom. Mean	Upper 80% Conf.Limit	Lower 80% Conf.Limit	Fecal Coli. Bact. as a % of Tot. Coli. Bact.	RATIO Fecal Coli. Bact. / Fecal Strep. Bact.
MISSOURI RIVER:												
Gavins Pt. Dam[1]	811.0	< 30	-	-	< 20	-	-	20	-	-	-	-
M-52A	732.8	1,040	2,200	50	190	550	130	280	470	100	30.8	1.4
M-48A	718.3	44,300	98,900	19,800	11,200	28,700	4,370	10,500	24,400	4,500	25.3	0.68
M-47	699.5	39,000	98,800	15,400	14,500	38,800	5,390	11,700	27,800	6,030	37.2	0.48
M-46	696.2	10,100	68,300	1,160	4,910	24,700	810	5,470	53,700	650	48.6	0.81
M-38	601.3	53,800	185,400	23,100	14,200	34,800	5,840	61,100	119,500	21,200	26.4	0.71
M-35	580.9	45,100	113,900	17,800	19,100	45,900	7,960	37,700	105,400	13,500	42.4	0.51
M-34	559.7	21,600	41,600	11,200	9,970	21,800	4,150	16,200	43,500	6,110	46.0	0.58
M-32	525.1	7,240	37,300	1,480	1,980	7,600	520	5,940	47,400	740	27.5	0.33
M-31[2]	488.1	95,200	161,600	56,100	5,840	18,300	1,660	17,300	51,300	5,840	6.1	0.34
M-28	452.3	15,800	138,800	1,580	2,830	13,900	400	5,490	57,800	550	17.9	0.51
M-27	440.3	17,300	201,400	1,480	3,740	22,900	690	5,960	46,800	760	21.7	0.63
M-26A	422.5	51,500	177,400	14,900	18,300	41,600	8,600	16,600	53,400	5,170	35.7	1.14
M-23	370.5	37,400	251,200	5,960	8,120	36,000	1,390	13,300	62,500	3,990	22.9	0.55
M-20A	338.3	136,500	374,700	49,700	18,600	51,700	6,100	33,300	71,800	6,730	13.6	0.84
M-18	345.4	87,400	297,400	25,700	24,900	94,900	6,190	25,700	95,300	6,990	27.7	0.94
M-17	334.5	188,000	477,700	34,300	23,900	56,600	10,100	97,600	259,100	10,200	12.7	0.90
M-15	293.4	150,300	342,500	66,000	19,500	43,000	8,870	50,900	150,100	6,300	13.0	0.93
M-14	270.0	140,500	942,300	20,900	13,700	94,500	4,110	18,300	69,600	4,450	14.0	1.06
M-12	241.2	87,300	383,600	23,600	5,560	13,600	2,280	11,800	47,900	2,950	6.4	0.80
M-9A	219.2	70,000	285,400	17,300	7,550	15,600	1,620	37,700	78,800	3,640	10.7	0.4
M-7A	174.8	189,500	736,100	27,800	5,370	16,300	2,100	15,000	145,400	2,590	4.2	0.27
M-5A	132.0	73,400	191,500	28,200	4,700	12,900	1,710	20,700	70,600	1,710	6.4	0.77
M-1	98.0	42,800	110,200	16,600	3,380	6,290	1,380	15,900	54,600	1,940	7.9	0.71
TRIBUTARIES:[3]												
PA-37A	596.5	4,040,000	9,970,000	1,710,000	591,200	1,130,000	310,100	534,300	1,573,000	189,100	14.6	1.11
P-37	594.8	36,000	143,600	9,000	18,700	60,600	3,730	8,360	63,000	1,080	51.9	2.39
WASTE SOURCES:[3]												
SC-49	789.0	19,460,000	57,930,000	6,540,000	5,150,000	20,000,000	1,330,000	8,760,080	37,670,000	9,040,000	26.5	0.99
CB-40B[4]	614.0	22,540,000	42,190,000	12,040,000	4,330,000	9,630,000	1,950,000	1,320,000	2,930,000	997,000	19.2	3.28
OM-40A[3]	611.5	11,180,000	33,730,000	3,700,000	3,000,000	14,990,000	600,300	16,650,000	62,120,000	4,460,000	26.8	0.18
K-19B[4]	367.2	8,940,000	26,630,000	3,000,000	1,760,000	5,220,000	1,460,000	5,050,000	11,310,000	2,260,000	20.9	0.54
K-19[2]	356.9	40,440,000	111,980,000	14,610,000	7,930,000	12,340,000	5,100,000	7,880,000	49,790,000	1,250,000	19.6	1.01

1/ Result for two discrete samples, 1/24 and 1/31/69.
2/ Result for 5 discrete samples, 1/20 - 1/24/69.
3/ River Mileage refers to point where tributary or waste source enters Missouri River.
Samples were collected on tributary or waste source upstream from confluence.
4/ Results for 5 discrete samples, 1/27 - 1/31/69.

TABLE NO. B-7

Summary of 5-Day Composite Samples

MISSOURI RIVER
October 7-18, 1968 Survey

STATION Name	River Mileage	TOT. PHOSPHORUS mg/l Normal 5-Day	TOT. PHOSPHORUS mg/l Wet 5-Day	NH_3 as N mg/l Normal 5-Day	NH_3 as N mg/l Wet 5-Day	NO_3 as N mg/l Normal 5-Day	NO_3 as N mg/l Wet 5-Day	ORG. N as N mg/l Normal 5-Day	ORG. N as N mg/l Wet 5-Day	TOT. NITROGEN mg/l Normal 5-Day	TOT. NITROGEN mg/l Wet 5-Day	TOT. ORG. CARBON mg/l Normal 5-Day	TOT. ORG. CARBON mg/l Wet 5-Day	Ca mg/l Avg. of Two 5-Day Samples	Mg mg/l Avg. of Two 5-Day Samples
MISSOURI RIVER:															
Gavins Pt. Dam[1]	811.0	0.04	0.03	0.08	0.06	0.2	0.3	0.4	0.2	0.7	0.6	5	6	66[1]	21[1]
M-52	796.0	0.05	0.07	0.09	0.12	0.2	0.4	1.2	0.4	1.5	0.9	5	5	69	20
M-50	730.0	0.07	0.11	0.20	0.16	0.2	0.2	1.0	0.4	1.4	0.8	6	6	70	20
M-48	717.4	0.07	0.11	< 0.01	0.20	0.2	0.2	0.7	0.6	0.9	1.0	135	7	70	20
M-47	699.5	0.06	0.15	0.20	0.26	0.2	0.3	0.8	0.6	1.2	1.2	6	7	68	19
M-46	676.5	0.07	0.12	0.15	0.15	0.2	0.2	0.9	0.7	1.2	1.1	6	5	67	20
M-44	654.6	0.08	0.54	0.24	0.27	0.3	0.4	0.8	1.5	1.1	2.2	5	13	68	21
M-42	626.2	0.12	0.49	0.07	0.19	0.3	0.4	0.9	1.3	1.3	1.7	6	10	65	20
M-41	618.3	0.20	0.40	0.12	0.17	0.3	0.4	0.8	2.0	1.2	2.6	8	9	92	6
M-39	610.5	0.24	0.37	0.17	0.22	0.4	0.4	0.8	1.5	1.3	2.1	8	10	68	20
M-38	601.3	0.20	0.35	0.09	0.15	0.3	0.4	0.9	1.1	1.3	1.6	7	13	69	20
M-36	591.2	0.30	0.35	0.07	0.47	0.4	0.4	1.0	1.5	1.5	2.4	6	11	64	19
M-35	580.9	0.29	0.30	0.14	0.52	0.3	0.4	1.2	1.1	1.9	2.0	9	10	70	21
M-34	559.7	0.25	0.70	0.19	0.51	0.3	0.6	1.0	2.0	1.5	3.1	9	21	68	20
M-33	546.7	0.27	0.73	0.13	1.13	0.4	0.6	1.4	2.2	1.9	3.9	9	18	70	20
M-32	525.1	0.26	0.60	0.13	1.55	0.3	0.5	1.9	1.9	2.3	4.0	8	16	66	19
M-31	507.5	0.27	0.58	0.14	0.10	0.4	0.6	1.5	1.8	2.0	2.6	7	14	66	19
M-30	488.3	0.26	0.73	0.25	0.26	0.3	0.7	1.0	2.0	1.6	3.0	9	19	68	22
M-29	469.0	0.33	0.92	0.17	0.20	0.3	1.0	1.1	2.8	1.6	4.1	9	24	69	21
M-28	452.3	0.26	0.60	0.18	0.21	0.4	0.7	2.3	1.6	2.9	2.5	7	16	69	20
M-27	440.3	0.25	0.56	0.19	0.27	0.4	0.6	2.7	1.3	3.3	2.2	8	14	72	19
TRIBUTARIES:[2]															
BS-51	734.0	0.29	0.32	0.39	0.62	0.2	1.3	1.9	1.2	2.5	3.1	13	9	94	37
S-45	664.0	0.17	3.00	0.10	0.72	0.5	1.6	0.7	7.4	1.3	9.7	5	50	72	37
B-43	635.1	2.10	2.85	0.64	0.52	3.0	3.5	5.7	4.9	9.3	8.9	40	37	72	36
FA-37A	596.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P-37	594.8	0.80	1.90	0.43	0.59	0.5	0.5	2.1	3.4	3.0	4.5	19	23	61	11
WASTE SOURCES:[2]															
SC-49	729.0	10.6	9.60	66.80	60.00	< 0.1	< 0.1	12.0	13.7	78.8	73.8	97	89	113	34
OM-40	611.5	11.4	12.0	36.8	39.8	0.5	< 0.1	30.0	100	67.2	139.8	212	278	70	21
CB-43B	634	-	-	-	-	-	-	-	-	-	-	-	-	-	-

1/ 5-Day Composite for typical Fall weather period 10/7-11/68.
2/ River Mileage refers to point where tributary or waste source enters Missouri River.
Samples were collected on tributary or waste source upstream from confluence.

TABLE NO. B-8

Average of Two 5-Day Composite Samples

MISSOURI RIVER
October 28-November 8, 1968 Survey

STATION Name	River Mileage	TOTAL PHOSPHORUS as P mg/l	NH_3 as N mg/l	NO_3 as N mg/l	ORGANIC N as N mg/l	TOTAL NITROGEN mg/l	TOTAL ORGANIC CARBON mg/l	Ca mg/l	Mg mg/l
MISSOURI RIVER:									
M-27	440.3	0.25	0.16	1.0	0.6	1.8	9	-	-
M-26[1]	422.6	0.22	< 0.01	1.4	0.5	1.9	8	-	-
M-25.5[2]	418.0	0.25	0.11	1.0	0.6	1.7	9	-	-
M-25	397.4	0.27	0.12	1.1	0.8	2.0	9	-	-
M-24	384.9	0.31	0.12	1.0	0.6	1.7	8	69	21
M-23	370.5	0.32	0.12	1.1	0.6	1.8	9	72	20
M-21	365.6	0.62	0.19	1.0	0.9	2.1	10	67	18
M-20	359.3	0.32	0.20	1.1	0.8	2.1	10	67	18
M-18	345.4	0.36	0.23	1.1	0.7	2.0	11	68	22
M-17	334.5	0.34	0.24	1.2	0.8	2.2	10	-	-
M-16	313.2	0.35	0.26	1.2	0.7	2.2	9	-	-
M-15	293.4	0.36	0.22	1.2	0.8	2.2	10	-	-
M-14	270.0	0.34	0.19	1.2	0.7	2.0	9	66	20
M-12	241.2	0.31	0.19	1.2	0.9	2.2	8	66	18
M-10	235.1	0.38	0.10	1.3	0.9	2.3	10	64	19
M- 9	221.0	0.40	0.10	1.3	0.8	2.2	9	63	20
M- 8	197.2	0.40	0.16	1.3	0.8	2.3	10	66	18
M- 7	179.0	0.38	0.16	1.2	1.7	3.1	9	71	18
M- 6	162.0	0.38	0.16	1.2	0.9	2.3	8	62	20
M- 5	139.0	0.38	0.14	0.8	0.8	1.7	9	64	18
M- 3	118.0	0.30	0.09	1.0	0.8	1.9	8	56	16
M- 1	98.0	0.30	0.10	1.0	0.8	1.9	10	56	17
TRIBUTARIES:[3]									
KR-22	367.4	0.46	0.23	1.2	0.8	2.2	11	-	-
GR-13	250.0	0.16	0.05	< 0.1	0.32	0.5	8	60	10
C-11	238.8	0.22	0.09	0.2	0.6	0.9	9	59	12
O- 4	130.0	0.08	0.10	0.4	0.4	0.90	6	46	10
G- 2	104.4	0.11	0.04	0.2	0.4	0.64	5	38	20
WASTE SOURCES:[3]									
K-19A[2]	367.20	12.0	33.0	1.2	9.5	43.7	82	-	-
K-19[1]	356.9	9.75	26.2	< 0.1	6.2	32.6	49	-	-

1/ Result of one 5-Day Composite for 10/28 - 11/1/68.
2/ Result of one 5-Day Composite for 11/4 - 11/8/68.
3/ River Mileage refers to point where tributary or waste source enters Missouri River.
Samples were collected on tributary or waste source upstream from confluence.

TABLE NO. B-9

Average of Two 5-Day Composite Samples

MISSOURI RIVER
January 20-February 2, 1969 Survey

STATION Name	River Mileage	TOTAL PHOSPHORUS as P mg/l	NH_3 as N mg/l	NO_3 as N mg/l	ORGANIC N as N mg/l	TOTAL NITROGEN mg/l	TOTAL ORGANIC CARBON mg/l	SPECIFIC CONDUC. µmhos/cm at 25° C.	Ca mg/l	Mg mg/l
MISSOURI RIVER:										
Gavins Pt. Dam	811.0	-	-	-	-	-	-	700	40	21
M-50A	732.8	0.04	0.14	0.4	1.2	1.8	5	800	41	23
M-48A	718.3	0.06	0.87	0.6	0.6	2.2	4	750	40	23
M-47	699.5	0.05	0.37	0.4	0.6	1.3	4	780	40	23
M-42	686.2	0.06	0.34	0.4	0.8	1.4	6	860	44	25
M-38	601.3	0.10	0.40	0.6	0.6	1.6	6	790	42	24
M-35	580.9	0.13	0.48	0.4	0.6	1.6	6	800	42	24
M-34	559.7	0.19	0.63	0.6	0.6	1.8	4	750	40	20
M-32	525.1	0.18	0.75	0.6	0.7	2.0	6	750	40	21
M-30[1]	488.3	0.20	0.75	0.5	0.8	2.1	6	690	38	19
M-28	452.3	0.30	0.81	0.6	0.8	2.2	6	770	41	20
M-27	440.3	0.20	0.78	0.4	0.8	2.0	6	710	41	20
M-26A	422.5	0.22	0.82	0.7	0.8	2.4	7	710	39	20
M-23	370.5	0.24	0.75	0.7	0.9	2.4	7	700	40	19
M-20A	358.3	0.30	0.87	0.6	1.2	2.7	8	710	41	19
M-18	345.4	0.28	0.82	0.9	1.0	2.8	8	710	40	19
M-17	334.5	0.32	0.80	0.8	1.2	2.7	8	700	40	19
M-15	293.4	0.52	0.94	0.8	1.6	3.3	12	700	40	19
M-14	270.0	0.40	0.82	0.7	1.1	2.6	9	700	40	19
M-12	241.2	0.36	0.78	0.8	1.2	2.8	10	690	37	19
M- 9A	219.2	0.44	0.74	0.9	1.6	3.3	12	550	30	16
M- 7A	174.8	0.54	0.60	0.8	1.8	3.1	13	490	25	14
M- 5A	132.0	0.56	0.64	0.7	1.8	3.2	16	570	26	15
M- 1	98.0	0.34	0.31	0.8	1.4	2.4	10	360	23	14
TRIBUTARIES:[2]										
PA-37A	596.5	6.45	27.0	1.0	3.8	31.8	22	990	43	22
P-37	594.8	0.32	0.41	0.8	0.6	1.9	5	690	26	14
WASTE SOURCES:[2]										
SC-49	789.0	14.2	59.2	< 0.01	14	73.2	65	2,980	52	36
CB-40B[3]	614	16.5	45.0	0.03	12	57.0	61	1,320	18	12
OM-40A[1]	611.5	6.90	20.2	0.7	5.9	26.8	30	1,580	38	22
K-19B[3]	367.19	5.55	19.5	0.3	4.6	24.4	28	2,360	42	10
K-19[1]	356.9	8.70	25.5	0.07	4.8	30.4	31	1,220	45	14

1/ Result of one 5-Day Composite for 1/20 - 1/24/69.
2/ Result of one 5-Day Composite for 1/27 - 1/31/69.
3/ River Mileage refers to point where tributary or waste source enters Missouri River.
Samples were collected on tributary or waste source upstream from confluence.

TABLE NO. B-10

Summary of Soluble Metals
Average of Two 5-Day Composite Samples

MISSOURI RIVER
October 7-18, 1968 Survey

STATION Name	River Mileage	Ba mg/l	Cd mg/l	Fe mg/l	Mn mg/l	Cr mg/l	As mg/l	Cu mg/l	Pb mg/l	Ni mg/l	Zn mg/l	B mg/l	Na mg/l	K mg/l	F mg/l
MISSOURI RIVER:															
Gavins Pt. Dam	811.0	< 1.0[1]	< 0.02[1]	< 0.30[1]	< 0.05[1]	< 0.05[1]	< 0.01	< 0.05[1]	< 0.05[1]	< 0.10[1]	< 0.05[1]	0.1	-	-	-
M-52	736.0	< 1.0	< 0.02	< 0.30	< 0.05	< 0.05	< 0.01	< 0.05	< 0.05	< 0.10	0.06	0.11	15	7.7	0.57
M-50	730.0	-	-	-	-	-	-	-	-	-	-	-	14	7.5	0.59
M-48	717.4	< 1.0	< 0.02	< 0.30	< 0.05	< 0.05	< 0.01	< 0.05	< 0.05	< 0.10	< 0.05	0.1	-	-	-
M-44	654.0	-	-	-	-	-	-	-	-	-	-	-	14	7.6	0.74
M-42	620.2	< 1.0	< 0.02	< 0.30	< 0.05	< 0.05	< 0.01	< 0.05	< 0.05	< 0.10	-	0.11	13	8.0	0.60
M-39	610.5	< 1.0	< 0.02	< 0.30	< 0.05	< 0.05	< 0.01	< 0.05	< 0.05	< 0.10	< 0.05	0.11	-	-	-
M-38	601.3	< 1.0	< 0.02	< 0.30	< 0.05	< 0.05	< 0.01	< 0.05	< 0.05	< 0.10	< 0.05	0.1	14	8.0	0.62
M-36	591.2	-	-	-	-	-	-	-	-	-	-	-	14	8.7	0.64
M-33	540.7	< 1.0	< 0.02	< 0.30	< 0.05	< 0.05	< 0.01	< 0.05	< 0.05	< 0.10	< 0.05	0.13	-	-	-
M-28	452.3	< 1.0	0.02	< 0.30	< 0.05	< 0.05	< 0.01	< 0.05	< 0.05	0.10	< 0.05	0.10	13	8.6	0.70
M-27	440.3	< 1.0	< 0.02	< 0.03	< 0.05	< 0.05	< 0.01	< 0.05	< 0.05	< 0.10	< 0.05	0.10	-	-	-

1/ 5-Day composite for typical Fall weather period 10/7-11/68 (Gavins Point Dam only).

TABLE NO. B-11

Summary of Soluble Metals
Average of Two 5-Day Composite Samples

MISSOURI RIVER
October 28-November 8, 1968 Survey

STATION Name	River Mileage	Ba mg/l	Cd mg/l	Fe mg/l	Mn mg/l	Tot. Cr mg/l	As mg/l	Cu mg/l	Pb mg/l	Ni mg/l	Zn mg/l	B mg/l	Na mg/l	K mg/l	F mg/l
MISSOURI RIVER:															
M-24	384.9	< 1.0	< 0.02	< 0.30	< 0.05	< 0.05	< 0.01	< 0.05	< 0.05	< 0.10	< 0.10	0.34	-	-	-
M-23	370.5	< 1.0	< 0.02	< 0.30	< 0.05	< 0.05	< 0.01	< 0.05	< 0.05	< 0.10	< 0.05	0.32	12	9.0	0.5
M-21	365.6	< 1.0	< 0.02	< 0.30	< 0.05	< 0.05	< 0.01	< 0.05	< 0.05	< 0.10	< 0.05	0.31	-	-	-
M-20	359.3	< 1.0	< 0.02	< 0.30	< 0.05	< 0.05	< 0.01	< 0.05	< 0.05	< 0.10	< 0.05	0.24	-	-	-
M-18	345.4	< 1.0	< 0.02	< 0.30	< 0.05	< 0.05	< 0.01	< 0.05	< 0.05	< 0.10	< 0.05	0.27	-	-	-
M-12	241.2	< 1.0	< 0.02	< 0.30	< 0.05	< 0.05	< 0.01	< 0.05	< 0.05	< 0.10	< 0.05	0.06	-	-	-
M- 7	179.0	< 1.0	< 0.02	< 0.30	< 0.05	< 0.05	< 0.01	< 0.05	< 0.05	< 0.10	< 0.05	0.05	-	-	-
M- 1	98.0	< 1.0	< 0.02	< 0.30	< 0.05	< 0.05	< 0.01	< 0.05	< 0.05	< 0.10	< 0.05	0.02	-	-	-

TABLE NO. B-12

Summary of Soluble Metals
Average of Two 5-Day Composite Samples

MISSOURI RIVER
January 20-February 2, 1969 Survey

STATION Name	River Mileage	Ba mg/l	Cd mg/l	Fe mg/l	Mn mg/l	Tot. Cr mg/l	As mg/l	Cu mg/l	Pb mg/l	Ni mg/l	Zn mg/l	B mg/l	Na mg/l	K mg/l	F mg/l
MISSOURI RIVER:															
M-52A	732.8	< 1.0	< 0.02	< 0.1	0.04	< 0.02	< 0.01	< 0.05	< 0.05	< 0.1	0.03	0.09	75	6.0	0.6
M-48A	718.3	< 1.0	< 0.02	< 0.1	0.05	< 0.02	< 0.01	< 0.05	0.085	< 0.1	0.07	-	-	-	-
M-42	626.2	< 1.0	< 0.02	0.1	0.03	< 0.02	< 0.02	< 0.05	< 0.05	< 0.1	0.07	0.10	81	6.6	0.6
M-38	601.3	< 1.0	< 0.02	< 0.1	0.04	< 0.02	< 0.02	< 0.05	< 0.05	< 0.1	0.08	0.10	70	6.2	0.6
M-28	452.3	< 1.0	< 0.02	< 0.1	0.04	< 0.02	< 0.01	< 0.05	< 0.05	< 0.1	0.025	0.12	55	7.5	0.6
M-27	440.3	< 1.0	< 0.02	< 0.2	0.04	< 0.02	< 0.01	< 0.05	< 0.05	< 0.1	0.055				
M-23	370.5	< 1.0	< 0.02	< 0.2	0.06	< 0.02	< 0.01	< 0.05	< 0.05	< 0.1	0.110	0.08	66	7.6	0.8
M-20A	358.3	< 1.0	< 0.02	0.1	0.04	< 0.02	< 0.01	< 0.05	< 0.05	< 0.1	0.115	-	-	-	-
M-18	345.4	< 1.0	< 0.02	0.3	0.07	< 0.02	< 0.01	< 0.05	< 0.05	< 0.1	0.105	-	-	-	-
M-12	241.2	< 1.0	< 0.02	< 0.1	0.06	< 0.02	0.01	< 0.05	< 0.05	< 0.1	< 0.02	-	-	-	-
M-7A	174.8	< 1.0	< 0.02	0.2	0.10	< 0.02	< 0.01	< 0.05	< 0.05	< 0.1	< 0.02	-	-	-	-
M-1	98.0	1.0	< 0.02	0.2	< 0.02	< 0.02	< 0.01	< 0.05	< 0.05	< 0.1	< 0.02	-	-	-	-

TABLE NO. B-13

Summary of Organic and Radioactive Constituents

MISSOURI RIVER
October 7-16, 1968 Survey

STATION Name	River Mileage	CYANIDE, µg/l Avg.[1]	CYANIDE, µg/l Max.	PHENOL, µg/l Avg.[2]	PHENOL, µg/l Max.	TOT.[3] ORG. CHLORINE µg/l	CHLOROFORM[3] EXTRACTS mg/l	URANIUM[4] µg/l	Ra-226[4] pc/l	THORIUM[4] µg/l	TOT.[3] α THORIUM pc/l	SOLUBLE[4] Sr-90 pc/l
MISSOURI RIVER:												
Gavins Pt. Dam	811.0	-	-	-	-	12[illegible]	[illegible]	-	-	-	-	-
M-52	736.0	< 4.3	12.2	< 1.5	2.0	-	-	4.3	0.08	< 4	< 0.[illegible]	2.2
M-48	717.4	6.2	14.0	< 1.5	2.0	[illegible]	0.0	-	-	-	-	-
M-42	626.2	< 2.7	9.4	-	-	158.2	26.1	-	-	-	-	-
M-39	610.5	< 5.1	8.4	< 1.5	2.0	-	-	-	-	-	-	-
M-38	601.3	< 1.0	< 1.0	< 1.5	2.0	24.[illegible]	9.4	-	-	-	-	-
M-36	591.2	-	-	-	-	-	-	2.3	0.07	< 4	< 0.67	1.9
M-33	546.7	5.6[2]	11.2	< 1.5	2.0	-	-	-	-	-	-	-
M-28	452.3	4.7	11.2	< 1.5	2.0	52.5	5.7	-	-	-	-	-
M-27	440.3	< 2.7	9.4	< 1.5	2.0	-	-	-	-	-	-	-
TRIBUTARIES:[6]												
BB-51	734.0	-	-	-	-	-	-	4.3	0.07	< 4	0.1[illegible]0.1[7]	1.2
S-45	664.0	-	-	-	-	-	-	3.9	0.07	< 4	< 0.18	1.0
B-43	635.1	-	-	-	-	-	-	4.1	0.19	< 4	< 0.18	1.6
P-37	594.8	-	-	-	-	-	-	6.4	0.12	< 4	0.30±0.22[7]	0.8
WASTE SOURCES:[6]												
CM-40	611.5	-	-	-	-	-	133.5	-	-	-	-	-

1/ Average of 3 to 4 grab samples during typical Fall and wet weather.
2/ Average of 2 grab samples during typical Fall weather.
3/ Single grab sample during typical Fall weather.
4/ Composite for 8 samples collected both during typical Fall weather and extremely wet weather.
5/ Includes a maximum discrete value of 15.2 µg/l.
6/ River Mileage refers to point where tributary or waste source enters Missouri River.
Samples were collected on tributary or waste source upstream from confluence.
7/ Counting error is expressed at the 95% confidence level.

TABLE NO. B-14

Summary of Organic and Radioactive Constituents

MISSOURI RIVER
October 28-November 8, 1968 Survey

STATION Name	River Mileage	CYANIDE, µg/l Avg. 1/	CYANIDE, µg/l Max.	PHENOL, µg/l Avg. 2/	PHENOL, µg/l Max.	TOT. 3/ CHLORINE µg/l	CHLOROFORM 3/ EXTRACTS mg/l	URANIUM 4/ µg/l	Ra-226 4/ pc/l	SOLUBLE 4/ Sr-90 pc/l
MISSOURI RIVER:										
M-24	564.9	< 1.0	< 1.0	< 10	< 10	-	-	-	-	-
M-23	470.5	< 2.4	[illegible]	< 10	< 10	43.9	0.0	-	-	-
M-21	393.0	< 1.0	< 1.0	< 10	< 10	-	-	-	-	-
M-20	359.3	< 3.6	7.0	< 10	< 10	-	-	-	-	-
M-18	345.4	< 1.0	< 1.0	< 10	< 10	90.6	25.5	-	-	-
M-14	270.0	-	-	-	-	-	-	4.3	0.07	1.7
M-12	241.2	< 1.0	< 1.0	1.2	1.4	-	-	-	-	-
M- 7	179.0	5.0	5.0	0.4	0.6	-	-	-	-	-
M- 3	118.0	-	-	-	-	90.7	3.6	-	-	-
M- 1	98.0	< 1.0	< 1.0	1.7	2.6	-	-	3.0	0.04	1.5
TRIBUTARIES: 5/										
KR-22	307.4	-	-	-	-	52.1	15.0	-	-	-
MR-13	290.0	-	-	-	-	-	-	2.0	0.03	1.5
C-11	238.8	-	-	-	-	-	-	1.6	0.02	1.4
O- 4	130.0	-	-	-	-	-	-	0.5	< 0.02	1.2
O- 2	104.4	-	-	-	-	-	-	0.5	0.03	-

1/ Average of 4 grab samples.
2/ Average of 2 grab samples.
3/ Single grab sample on 11/1/68.
4/ Composite of 5 grab samples, daily from 11/4 - 11/8/68.
5/ River Mileage refers to point where tributary or waste source enters Missouri River. Samples were collected on tributary or waste source upstream from confluence.

TABLE NO. B-15

Summary of Organic Constituents

MISSOURI RIVER
January 20-February 2, 196[illegible] Survey

STATION Name	River Mileage	CYANIDE, µg/l Avg.[1]	CYANIDE, µg/l Max.	PHENOL, µg/l Avg.[1]	PHENOL, µg/l Max.	TOT.[2] ORG. CHLORINE µg/l
MISSOURI RIVER:						
Gavins Pt. Dam	811.0	-	-	-	-	46.2
M-52A	732.8	< 1.2	2.0	< 1.2	1.6	-
M-48A	718.3	1.9	3.8	< 1.2	1.6	22.2
M-42	626.2	< 2.7	7.7	< 1.9	4.0	40.1
M-38	601.3	< 1.8	2.6	< 1.0	< 1.0	33.0
M-28	452.3	< 1.9	3.6	< 2	< 2	73.1
M-27	440.3	< 1.7	3.2	< 2	< 2	-
M-23	370.5	< 1.2	1.6	< 2.7	4.0	42.1
M-20A	358.3	< 1.0	< 1.0	5.0	9.0	-
M-18	345.4	< 3.0	7.0	8.7	16.0	38.1
M-12	241.2	< 1.6	2.8	< 1.3	2.2	-
M- 7A	174.8	< 1.2	1.6	< 1.2	1.6	-
M- 1	98.0	< 1.0	< 1.0	< 1.2	1.6	74.4
TRIBUTARIES:[3]						
P-37	594.8	-	-	-	-	72.0

1/ Average of 3 to 4 grab samples.
2/ Single grab sample.
3/ River Mileage refers to point where tributary or waste source enters Missouri River.
Samples were collected on tributary or waste source upstream from confluence.

TABLE NO. B-16

Bottom Associated Animals

MISSOURI RIVER
October 1968

Organism	Station (River Mile) 736	730	717	699	676	655	626	618	Big Sioux River 724-1	Floyd River 731-.01	Soldier River 664-1	Boyer River 635-3
Sensitive Organisms												
Stoneflies												
Perlodidae	-	-	-	-	Q	-	-	-	-	-	-	-
Acroneuria	-	-	-	Q	-	Q	-	-	-	-	-	-
Mayflies												
Ameletus	-	-	-	-	-	Q	Q	-	-	-	-	4
Caenis	-	-	-	-	-	-	-	Q	-	-	-	-
Heptagenia	-	-	Q	Q	-	Q	Q	Q	-	-	-	-
Hexagenia	-	-	-	Q	-	-	-	-	-	-	-	-
Isonychia	Q	Q	Q	Q	Q	Q	-	-	-	-	-	-
Stenonema	Q	-	Q	Q	Q	Q	-	Q	-	-	-	-
Tricorythodes	-	-	-	-	-	-	-	Q	-	-	-	-
Caddisflies												
Cheumatopsyche	-	-	-	-	-	Q	-	-	-	-	-	-
Hydropsyche	Q	Q	Q	Q	Q	Q	Q	Q	Q	-	-	-
Neureclipsis	Q	Q	Q	Q	-	Q	Q	Q	-	-	-	-
Potamyia	-	-	-	-	Q	-	-	-	-	-	-	-
Psychomyia	-	-	-	-	Q	-	-	-	-	-	-	-
Subtotal/sq. ft.	-	-	-	-	-	-	-	-	-	0	0	4
Subtotal/kinds	4	3	5	7	6	8	4	6	1	0	0	1
Intermediate Organisms												
Midges												
Cricotopus	-	Q	-	Q	-	-	Q	Q	-	-	-	-
Glyptotendipes	Q	-	Q	-	-	-	-	-	Q	-	Q	-
Orthocladius	-	-	-	-	-	Q	-	-	-	-	-	-
Polypedilum	-	-	-	-	-	Q	Q	Q	-	-	8	Q
Procladius	-	-	-	-	-	-	Q	-	-	-	-	-
Psectrocladius	-	Q	-	-	-	-	-	Q	-	-	Q	-
Pseudochironomus	-	-	-	-	-	-	-	-	-	-	Q	-
Tanytarsus	-	-	-	-	-	-	-	Q	-	-	-	-
Craneflies												
Eriopters	-	-	-	-	-	-	-	-	-	-	-	Q
Blackflies												
Simulium	-	-	-	-	-	-	-	-	-	-	Q	-
Damselflies												
Amphiagrion	-	-	-	-	-	-	-	-	-	-	Q	-
Argia	-	-	-	-	-	Q	-	-	-	-	Q	-
Scuds												
Gammarus	-	Q	-	-	-	-	-	-	-	-	-	Q
Hyalella	Q	-	-	-	Q	Q	-	Q	Q	-	-	Q
Limpets												
Ancylidae	-	-	-	-	-	-	-	-	-	-	Q	Q
Clams												
Sphaeriidae	-	-	-	-	-	-	-	-	-	-	4	-
Sow Bugs												
Asellus	-	Q	Q	Q	Q	Q	-	-	-	-	-	-
Subtotal/sq. ft.	-	-	-	-	-	-	-	-	-	0	12	-
Subtotal/kinds	2	4	2	2	2	5	3	5	2	0	9	5
Tolerant Organisms												
Snails												
Physa	-	Q	Q	Q	Q	-	-	Q	Q	-	-	-
Leeches												
Hirudidae	Q	-	Q	Q	Q	Q	Q	-	Q	-	-	Q
Bloodworms												
Chironomus	Q	Q	Q	Q	Q	-	Q	-	Q	-	4	Q
Sludgeworms												
Tubificidae	Q	4	-	Q	-	-	-	Q	280	6	8	304
Subtotal/sq. ft.	-	-	-	-	-	-	-	-	280	6	12	304
Subtotal/kinds	3	3	3	4	3	1	2	2	4	1	2	3
Grand Total/sq. ft.	-	-	-	-	-	-	-	-	280	6	24	308
Number of Kinds	9	10	10	13	11	14	9	13	7	1	11	9

Q = Organisms collected qualitatively.

TABLE NO. B-16
(contd)
1

Bottom Associated Animals

MISSOURI RIVER
October 1968

Organisms	Station (River Mile) 610	601	591	581	560	547	525	507	488	469	452	440	423	397	385	Platte River 595-.5
Sensitive Organisms																
Mayflies																
Ameletus	Q	-	-	Q	-	-	-	-	-	Q	Q	Q	-	-	-	-
Baetis	-	-	-	-	-	-	-	-	-	-	-	Q	-	-	-	-
Heptagenia	-	-	-	Q	-	-	-	Q	-	Q	Q	Q	Q	Q	-	Q
Isonychia	-	-	-	-	-	-	-	-	-	-	-	Q	-	-	-	-
Stenacron	Q	-	-	Q	Q	-	Q	Q	Q	Q	Q	Q	-	Q	Q	Q
Paraleptophlebia	-	-	-	-	-	-	-	-	-	-	-	-	-	Q	-	-
Caddisflies																
Cheumatopsyche	Q	Q	-	-	-	-	Q	-	2	Q	-	-	Q	-	Q	Q
Hydropsyche	-	-	-	Q	-	-	-	Q	-	Q	-	Q	-	Q	-	Q
Neureclipsis	-	-	-	-	-	-	Q	-	-	Q	Q	Q	Q	-	-	-
Subtotal/sq. ft.	-	-	-	-	-	-	-	-	2	-	4	-	-	-	-	-
Subtotal Kinds	3	1	0	5	1	0	3	3	2	6	4	5	3	4	2	4
Intermediate Organisms																
Beetles																
Cymbiodyta	-	-	Q	-	-	-	-	-	-	-	-	-	-	-	-	-
Midges																
Cardiocladius	-	Q	-	-	-	-	-	-	-	Q	Q	-	-	-	-	-
Chironomus	-	-	-	-	-	-	-	-	2	-	-	Q	-	-	2	-
Clinotanypus	-	Q	-	-	-	-	-	-	-	-	-	Q	-	-	Q	-
Cricotopus	Q	Q	-	-	-	-	-	-	-	Q	Q	Q	-	-	Q	-
Glyptotendipes	-	-	-	-	-	-	-	Q	-	-	-	Q	-	-	-	-
Orthocladius	-	-	-	-	-	-	-	-	-	-	-	Q	-	-	-	-
Pentaneura	-	-	-	-	Q	-	-	-	-	-	-	Q	-	-	-	-
Polypedilum	Q	4	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	-	-	-	-
Procladius	-	Q	-	Q	-	-	-	-	-	-	-	-	-	Q	Q	Q
Psectrocladius	-	4	-	4	-	-	-	-	-	-	-	-	-	-	-	Q
Spaniotoma	Q	Q	-	-	Q	-	Q	-	Q	Q	Q	-	-	-	Q	-
Tanytarsus	Q	Q	-	-	-	-	Q	-	-	Q	-	Q	Q	-	Q	-
Tanypus	-	-	-	-	-	-	-	4	-	-	-	Q	-	-	Q	Q
Psectrotanypus	-	-	-	Q	-	-	-	-	-	-	-	-	-	-	Q	-
Craneflies																
Erioptera	-	-	-	-	-	-	-	-	-	-	Q	-	-	-	-	-
Limonia	-	-	-	-	-	-	Q	-	-	-	-	-	-	-	-	-
Blackflies																
Simulium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Q
Damselflies																
Amphiagrion	-	-	-	Q	-	-	-	-	-	-	-	-	-	-	Q	-
Argia	-	-	-	Q	-	-	-	Q	-	-	Q	-	-	-	-	-
Scuds																
Crangonyx	-	-	-	-	Q	-	Q	-	Q	Q	-	-	-	-	-	-
Gammarus	-	-	-	Q	-	-	-	-	-	-	-	-	-	-	-	-
Hyalella	-	-	Q	-	Q	Q	-	Q	-	Q	Q	-	-	-	-	-
Sow Bugs																
Asellus	-	Q	-	-	-	-	-	Q	-	Q	-	-	-	-	-	-
Limpet																
Ancylidae	-	-	-	-	-	-	-	-	-	-	-	Q	Q	-	Q	-
Subtotal/sq. ft.	4	12	3	7	5	2	6	9	5	9	8	-	-	-	2	-
Subtotal Kinds	4	9	3	7	5	2	6	6	4	9	8	8	2	1	9	4
Tolerant Organisms																
Snails																
Physa	-	Q	Q	Q	Q	-	-	-	-	-	Q	-	Q	Q	-	-
Leeches																
Hirudidae	Q	Q	-	Q	-	-	Q	-	-	Q	-	-	Q	-	-	Q
Bloodworms																
Chironomus	-	-	-	Q	-	-	-	Q	-	8	-	-	-	Q	-	-
Sludgeworms																
Tubificidae	Q	190	100	Q	200	180	320	120	90	580	Q	Q	10	-	50	Q
Subtotal/sq. ft.	-	190	100	-	200	180	320	120	90	588	-	1	10	-	50	-
Subtotal/kinds	2	3	2	4	2	1	2	2	1	3	2	1	3	2	1	2
Grand Total/sq. ft.	-	194	100	-	00	180	320	124	94	588	-	4	10	-	52	-
Number of Kinds	9	13	5	16	8	3	11	11	7	18	14	14	8	7	12	10

Q = Organisms collected qualitatively.

TABLE IV, D-16
(cont'd)

Bottom Associated Animals

MISSOURI RIVER
October 1968

Organism	Station (River Mile) 370	359	356	345	334	313	293	270	238	235	221	197	179	162	139	118	98	Kansas River 367-.5	Blue River 338-.1	Grand River 250-.5	Osage River 130-.5	Gasconade River 104-.8
Sensitive Organisms																						
Mayflies																						
Ameletus	Q	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Caenis	Q	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hentagenia	Q	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hexagenia	4	-	-	-	-	-	-	Q	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Isonychia	-	-	-	-	-	-	-	-	-	-	-	-	8	100	-	24	62	-	-	-	-	-
Paraclaeodes	-	Q	-	-	-	-	-	-	-	-	-	-	Q	-	-	-	-	-	-	-	28	24
Stenonema	Q	Q	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tricorythodes	-	-	-	-	-	-	-	Q	-	Q	Q	Q	-	4	4	-	Q	-	-	Q	-	-
Caddisflies																						
Cheumatopsyche	Q	-	-	-	-	-	-	-	Q	-	-	-	-	-	-	-	Q	-	-	-	-	-
Hydropsyche	Q	-	-	-	-	-	-	Q	-	-	Q	-	-	-	-	-	Q	-	-	-	-	-
Potamyia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Q	-	-	-	-	-
Subtotal/sq. ft.	4	-	-	-	-	-	-	-	-	-	-	-	8	104	-	24	62	-	-	-	28	24
Subtotal/Kinds	7	2	0	0	0	0	0	3	1	1	2	1	2	2	1	1	5	0	0	2	1	1
Intermediate Organisms																						
Beetles																						
Dineutus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Narpus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
Midges																						
Alblabesmyia	-	-	-	-	-	-	Q	4	-	-	-	-	-	-	-	-	-	-	-	-	2	-
Chironomus	Q	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-
Cricotopus	-	-	4	-	-	-	-	-	Q	-	Q	-	-	-	-	-	-	-	-	-	-	-
Glyptotendipes	-	-	-	-	-	-	-	-	Q	-	Q	-	-	-	-	-	-	-	-	-	-	-
Paralauterborniella	-	-	-	-	-	-	-	-	Q	-	-	-	-	-	-	-	-	-	-	Q	-	-
Polypedilum	2	4	-	4	4	-	-	Q	Q	Q	Q	Q	Q	-	-	-	-	-	-	-	-	-
Procladius	-	-	-	-	-	-	-	Q	Q	Q	Q	Q	Q	-	-	-	-	64	-	Q	-	4
Psectrocladius	-	-	-	2	-	-	-	-	-	-	-	-	4	4	-	-	4	-	-	-	-	-
Pseudochironomus	-	-	-	-	Q	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spaniotoma	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tanytarsus	Q	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tanypus	-	-	-	-	-	-	-	Q	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phantom Midges																						
Chaoborus	4	-	-	-	-	-	-	Q	Q	Q	-	-	Q	-	-	-	-	28	-	-	2	-
Mosquitoes																						
Anopheles	Q	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Craneflies	-	-	-	-	-	-	-	-	-	-	-	Q	-	-	-	-	-	-	-	-	-	-
Mothflies																						
Pericoma	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-
Damselflies																						
Amphiagrion	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Argia	-	-	-	-	Q	Q	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Erallagma	-	-	-	-	-	-	Q	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ischnura	-	Q	-	-	-	-	-	-	-	-	-	-	-	Q	-	-	Q	-	-	Q	-	-
Scuds																						
Crangonyx	Q	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hyalella	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Limpets																						
Ancylidae	4	-	-	Q	-	2	Q	Q	Q	-	Q	-	-	Q	-	-	-	-	-	Q	-	-
Flatworms																						
Turbellaria	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-
Biting Midges																						
Bezzia	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	4
Clams																						
Sphaeriidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-
Sphaerium	-	-	-	-	-	-	-	-	-	Q	-	-	-	-	-	-	-	-	-	-	-	-
Subtotal/sq. ft.	1	-	4	-	-	-	4	-	-	-	-	4	8	-	-	4	102	-	8	8	-	40
Subtotal/Kinds	8	2	1	3	3	1	3	5	4	4	3	2	3	4	0	0	3	3	0	5	3	4
Tolerant Organisms																						
Snails																						
Physa	-	Q	Q	Q	4	Q	-	-	-	-	-	-	Q	4	-	-	Q	-	-	-	4	-
Leeches																						
Erpobdellidae	-	Q	4	Q	Q	Q	-	Q	-	-	-	-	Q	-	-	-	Q	-	-	-	-	-
Glossiphonia	-	-	-	-	-	-	-	-	-	-	-	-	Q	-	-	-	-	-	-	-	-	-
Chironomus	-	Q	Q	-	6	Q	-	-	-	Q	-	Q	Q	-	-	-	2	-	-	-	-	-
Sludgeworms																						
Tubificidae	590	Q	62	552	100	356	120	60	96	56	168	48	292	56	232	252	100	980	-	40	3	40
Subtotal/sq. ft.	590	4	66	552	100	356	120	60	96	56	168	48	312	60	232	252	102	1020	0	44	13	40
Subtotal/Kinds	1	4	4	3	4	4	1	2	1	2	1	2	4	2	1	1	3	2	0	2	3	1
Grand total/sq. ft.	606	8	70	[illegible]	[illegible]	[illegible]	124	64	96	56	168	48	404	[illegible]	3	276	176	1122	-	52	49	124
Grand total - Number of kinds	16	8	5	6	7	7	4	10	6	7	6	5	9	8	2	2	11	5	0	9	7	6

Q = Organisms collected qualitatively.

TABLE NO. B-17

Suspended Algae

MISSOURI RIVER
OCTOBER-NOVEMBER, 1968

STATION	River Mile	Number/ ml	Cell Vol. (ppm)
M-52	736.0	872	0.84
M-50	730.0	728	1.34
M-48	717.4	339	1.01
M-47	699.5	749	1.24
M-46	676.5	687	0.93
M-44	654.6	893	1.54
M-42	626.2	966	1.85
M-41	618.3	996	2.23
M-39	610.5	453	0.65
M-38	601.3	817	5.44
M-36	591.2	947	1.92
M-35	580.9	1,654	2.17
M-34	559.7	5,995	5.82
M-33	546.7	3,791	3.53
M-32	525.1	2,584	2.51
M-31	507.5	3,046	2.93
M-30	488.3	1,769	2.63
M-29	469.0	1,905	3.51
M-28	452.3	1,366	1.85
M-27	440.3	2,144	4.65

TABLE NO. B-17
(contd.)
1

Suspended Algae
MISSOURI RIVER
OCTOBER-NOVEMBER, 1968

STATION	River Mile	Number/ ml	Cell Vol. (ppm)
M-26	422.6	2,178	3.21
M-25	397.4	1,584	2.85
M-24	384.9	1,863	5.34
M-23	370.5	1,749	3.83
M-21	365.6	1,798	2.67
M-20	359.3	1,699	4.48
M-18	345.4	1,600	1.67
M-17	334.5	1,727	2.84
M-16	313.2	2,013	1.37
M-15	293.4	1,617	2.32
M-14	270.0	782	0.59
M-12	241.2	765	0.73
M-10	235.1	603	0.58
M- 9	221.0	471	0.64
M- 8	197.2	605	0.90
M- 7	179.0	815	0.86
M- 6	162.0	1,016	1.30
M- 5	139.0	895	0.87
M- 3	118.0	1,593	1.54
M- 1	98.0	826	0.85

TABLE NO. B-17
(contd.)
2

Suspended Algae
MISSOURI RIVER
OCTOBER-NOVEMBER, 1968

STATION	River Mile	Number/ ml	Cell Vol. (ppm)
TRIBUTARY STREAMS			
		BIG SIOUX RIVER	
BS-51	734.0	11,653	11.75
		SOLDIER RIVER	
S-45	664.0	644	0.61
		BOYER RIVER	
B-43	635.1	961	0.88
		PLATTE RIVER	
P-37	594.8	9,236	13.04
		KANSAS RIVER	
Kr-22	367.4	1,815	0.86
		GRAND RIVER	
GR-13	250.0	10,649	6.04
		CHARITON RIVER	
C-11	238.8	2,986	4.76
		OSAGE RIVER	
O- 4	130.0	943	1.16
		GASCONADE RIVER	
G- 2	104.4	851	1.26

APPENDIX C

DETERMINATION OF BOD EXERTION RATES

MISSOURI RIVER

The biochemical oxygen demand (BOD) test is an empirical bioassay-type procedure which measures the oxygen consumed by microbiological organisms during the assimilation of the organic matter present. The BOD can exert a significant influence on water quality by depleting the dissolved oxygen concentration to levels that can damage beneficial water uses. Although no known damages to beneficial water uses because of the BOD depleting the D.O. were known to occur in the Missouri River during these surveys, low dissolved oxygen concentrations did occur during the peak run-off period of October 17 and 18, 1968. The minimum observed D.O. was 4.5 mg/l at Station M-28, near the St. Joseph, Missouri water intake. The corresponding BOD_5 was 8 mg/l. During the January, 1969 survey, the effects of an ice cover significantly reduced reaeration, and D.O.'s were reduced by BOD exertion.

There is only a remote possibility that D.O. could be suppressed to levels that would damage aquatic life in the Missouri River. Such an occurrence would likely occur during heavy run-off from large areas of the watershed, including scouring of organic bottom deposits and hydraulic overflows containing sewage and packinghouse wastes. The Missouri River downstream from Omaha is the reach where the probability is greatest for such an occurrence; the organic loads are greatest, the watershed most subject to erosion, and the climate most appropriate.

The following limited objectives required a more detailed analysis of the BOD data:

1. To calculate BOD's at exactly 2.0 and 5.0 days from nominal values of observed BOD, which were incubated at various times near 2.0 and 5.0 days. All average BOD concentrations at Missouri River stations were found to be within $\pm$ 0.1 mg/l of the calculated "exact" results.

2. To determine BOD exertion rate constants(k_1).

3. To discuss the BOD results obtained during this survey which may be helpful in future water quality surveys of the Missouri River.

The primary assumptions for the BOD calculations made were that the kinetics of the BOD reactions observed at all stations were "first-order," and that nitrification (second stage BOD) was not an effect within the 5-day time of incubation. These assumptions were generally confirmed by the 20-day BOD results determined at selected stations.

For each daily sample, the k_1's were computed using the nominal BOD_2 and BOD_5 concentrations and exact incubation times to the nearest 0.001 day. Because of the low precision in the BOD test at low concentrations, the standard deviation about the mean of the daily k_1's at a station commonly equalled one-half the calculated k_1, and occasionally exceeded k_1. The mean of a set of individual k_1's at a station had little meaning when the variability of the individual samples was great. A more meaningful statistical method was used: the daily BOD_2's and BOD_5's and incubation times at each station were averaged for each of the survey periods and using first order kinetics, a value of k_1 was determined. This procedure yielded more significant results.

The reaction rates (k_1) determined for each station were graphed versus time-of-water travel for the autumn survey (Figure C-1 and C-2) and versus river mile for the winter survey (Figure C-3). Trend lines drawn through the graphed points indicate that the rate of BOD satisfaction decreases downstream from the major waste discharges. This effect occurs because the less readily biodegradable compounds remain as the microbiological assimilation and oxidation progresses and thus, dissolved oxygen is consumed at a reduced rate.

At stations where flows were available or could be accurately calculated, the BOD_5 loads (as pounds per day) were computed for the fall navigational period (Figure C-4). Flows are plotted and connected so that the build-up of BOD loads could be shown with respect to river discharge.

Because of hazards to small boats on the Missouri River during high runoff periods, only one sample was obtained for many stations in the period of rain-affected runoff, October 17 and 18, 1968. The k_1 for individual samples and the k_1 from the average of two samples ranged from 0.02 to 0.16 per day during this period. Organic materials ranged from the highly inert to the highly biodegradable such as sewage. Results from the analysis, including k_1, BOD_L, and BOD_5 load for tributaries and waste sources studied, are in Table C-1. The BOD load analysis shows the relative importance of the various waste sources and tributaries contributing oxidizable organic pollution.

TABLE NO. C-1

Summary of BOD Characteristics for Tributaries and Waste Sources
MISSOURI RIVER
Autumn and Rain-affected Period, 1968 and Winter, 1969 Surveys

STATION NAME	AUTUMN, 1968 SAMPLING PERIOD	K_1 Base 10 per Day	BOD_L mg/l	BOD Load lbs./Day	RAIN-AFFECTED PERIOD, 1968 SAMPLING PERIOD	K_1 Base 10 per Day	BOD_L mg/l	BOD Load lbs./Day	WINTER, 1969 SAMPLING PERIOD	K_1 Base 10 per Day	BOD_L mg/l	BOD Load lbs./Day
TRIBUTARIES:												
BS-51	10/8-16/68	0.10	13.4	8,400	10/17-18/68	0.13	8.1	24,000	-	-	-	-
S-45	10/7-11/68	0.17	7.7	400	10/16-18/68	0.31	7.2	41,300	-	-	-	-
B-43	10/8-16/68	0.09	14.6	18,000	10/17-18/68	0.13	18.5	117,000	-	-	-	-
PA-37A	-	-	-	-	10/16-18/68	0.02	552	119,000[1]	1/20-31/69	0.06	164	99,600[2]
P-37	10/8-16/68	0.08	13.4	158,000	10/17-18/68	0.05	20.9	756,000	1/20-31/69	0.08	3.5	40,300
KR-29	10/28-11/8/68	0.09	4.9	111,000	-	-	-	-	-	-	-	-
GR-13	10/28-11/8/68	0.10	5.0	2,800	-	-	-	-	-	-	-	-
C-11	10/28-11/8/68	0.12	4.4	1,000	-	-	-	-	-	-	-	-
G-4	10/28-11/8/68	0.14	2.1	53,400	-	-	-	-	-	-	-	-
G-2	10/28-11/8/68	0.16	3.8	43,400	-	-	-	-	-	-	-	-
WASTE SOURCES:												
SC-49	10/6-15/68	0.15	303	33,300	10/16-17/68	0.18	305	40,900	1/20-31/69	0.14	491	41,700
SB-40B	-	-	-	-	-	-	-	-	1/27-31/69	0.08	558	14,200
SM-40	10/8-15/68	0.13	1,350	258,000	10/16-18/68	0.20	463	505,000	-	-	-	-
SM-40A	-	-	-	-	-	-	-	-	1/20-23/69	0.12	377	34,200
K-19A	11/4- 8/68	0.11	385	18,300	-	-	-	-	-	-	-	-
K-19B	-	-	-	-	-	-	-	-	1/27-31/69	0.13	161	17,800
K-19	10/28-11/1/68	0.28	179	61,900	-	-	-	-	1/20-24/69	0.18	154	66,800

1/ Based on estimated average flow of 150 cfs.

2/ Based on estimated average flow of 50 cfs.

C-3-4

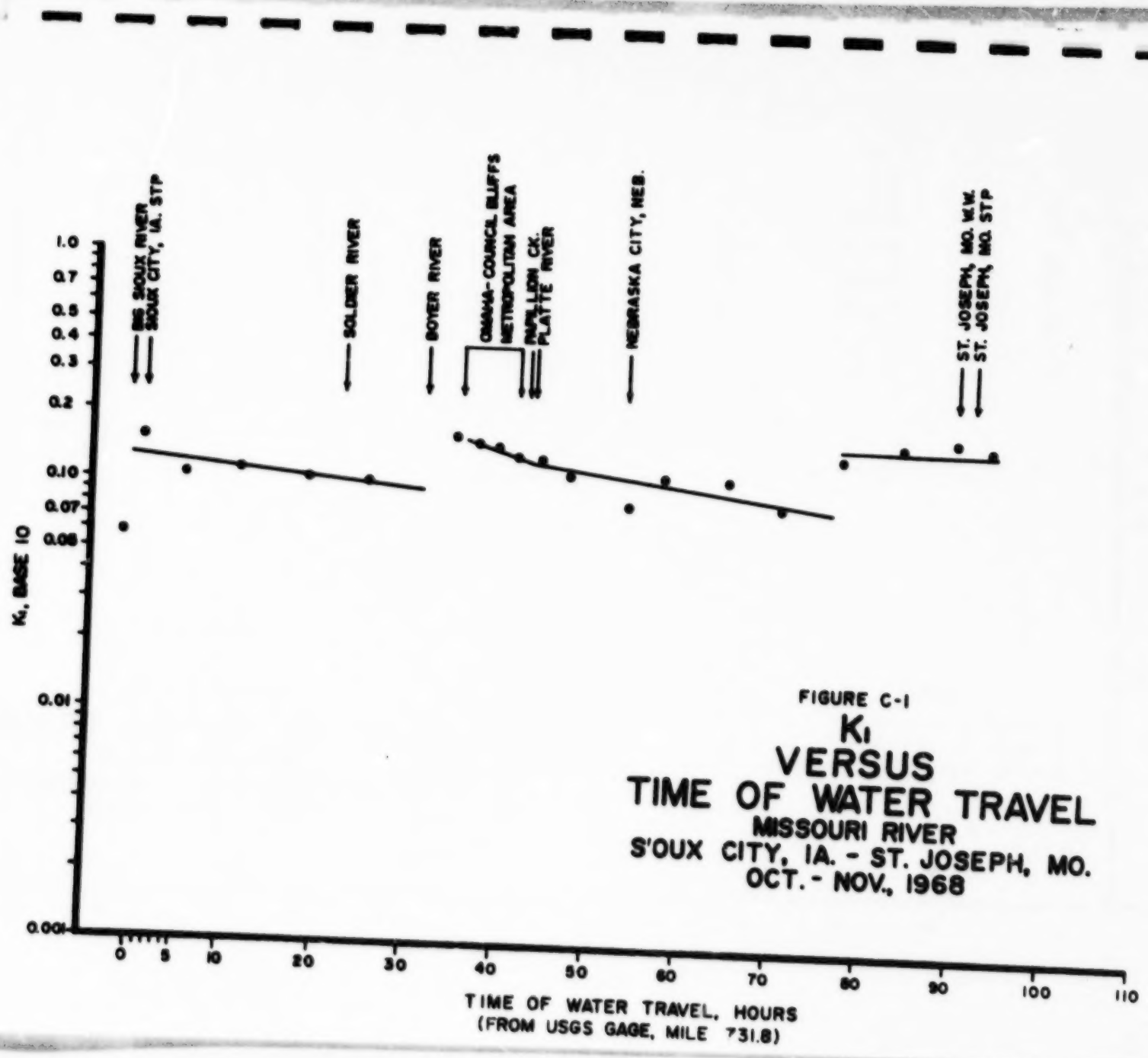
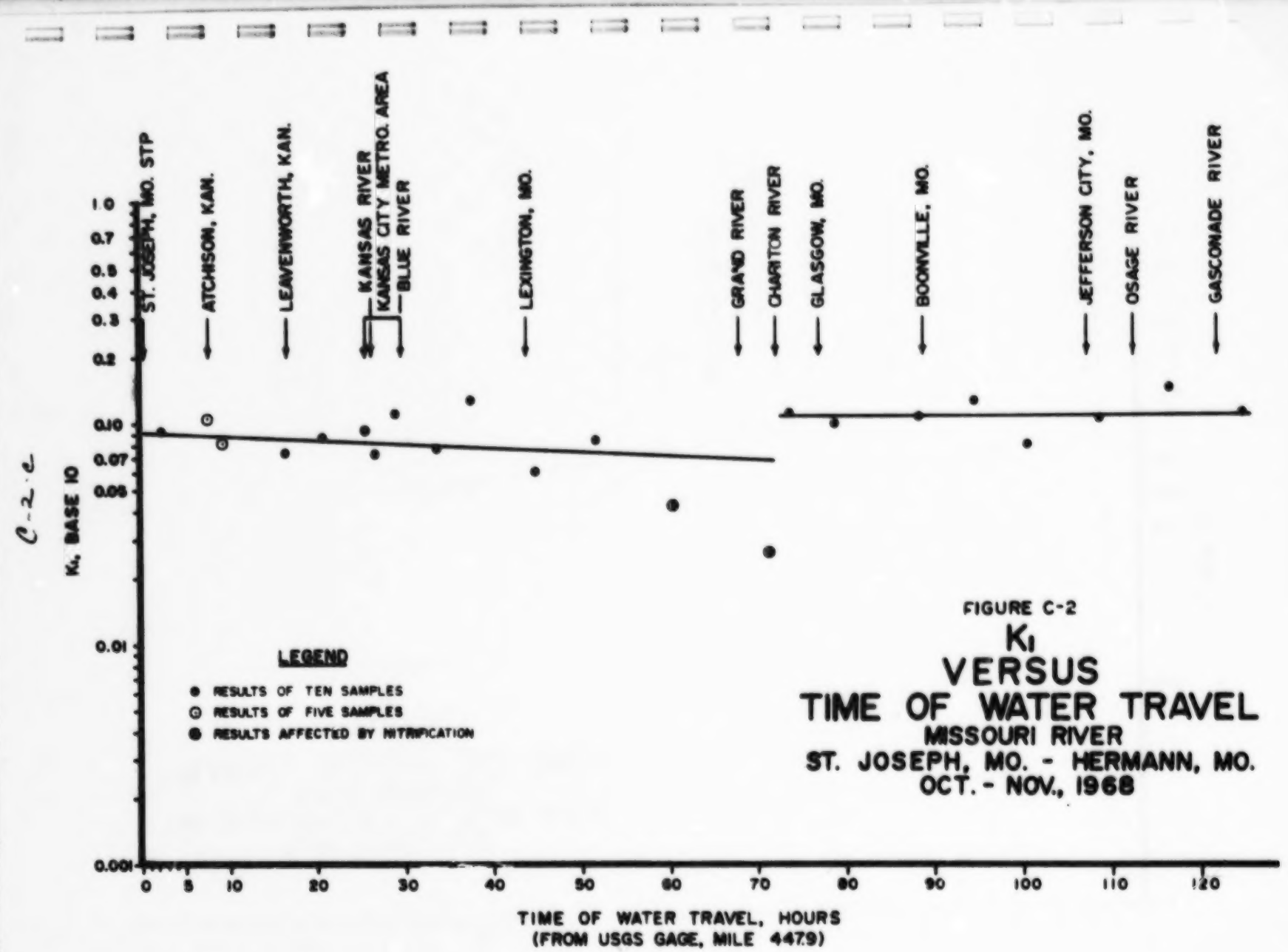


FIGURE C-1

K_1 VERSUS TIME OF WATER TRAVEL

MISSOURI RIVER
S'OUX CITY, IA. - ST. JOSEPH, MO.
OCT. - NOV., 1968

C-3 b



C-2-e

FIGURE C-2

K_1 VERSUS TIME OF WATER TRAVEL

MISSOURI RIVER

ST. JOSEPH, MO. - HERMANN, MO.

OCT. - NOV., 1968

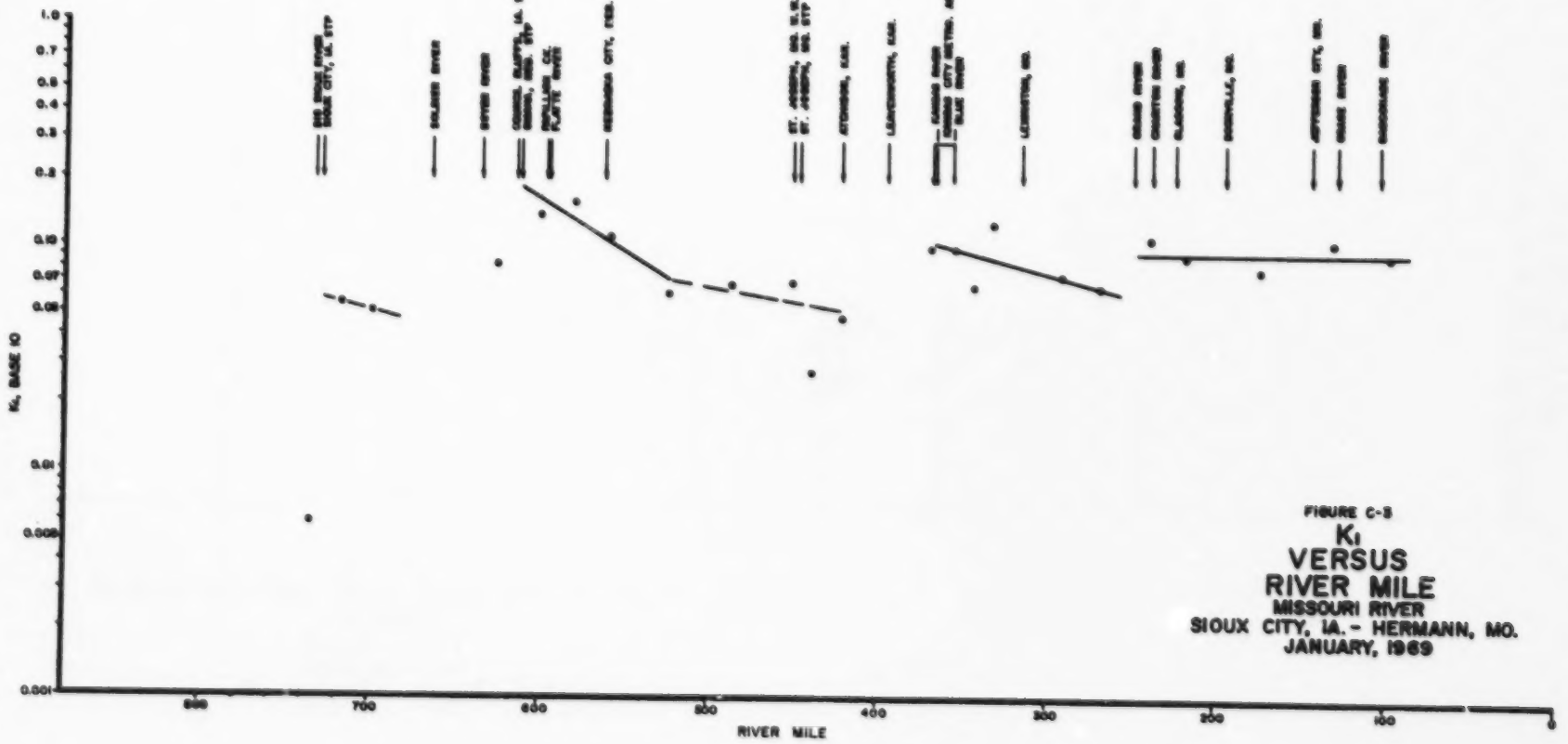


FIGURE C-3
K_1
VERSUS
RIVER MILE
MISSOURI RIVER
SIOUX CITY, IA. - HERMANN, MO.
JANUARY, 1969

C-2-F

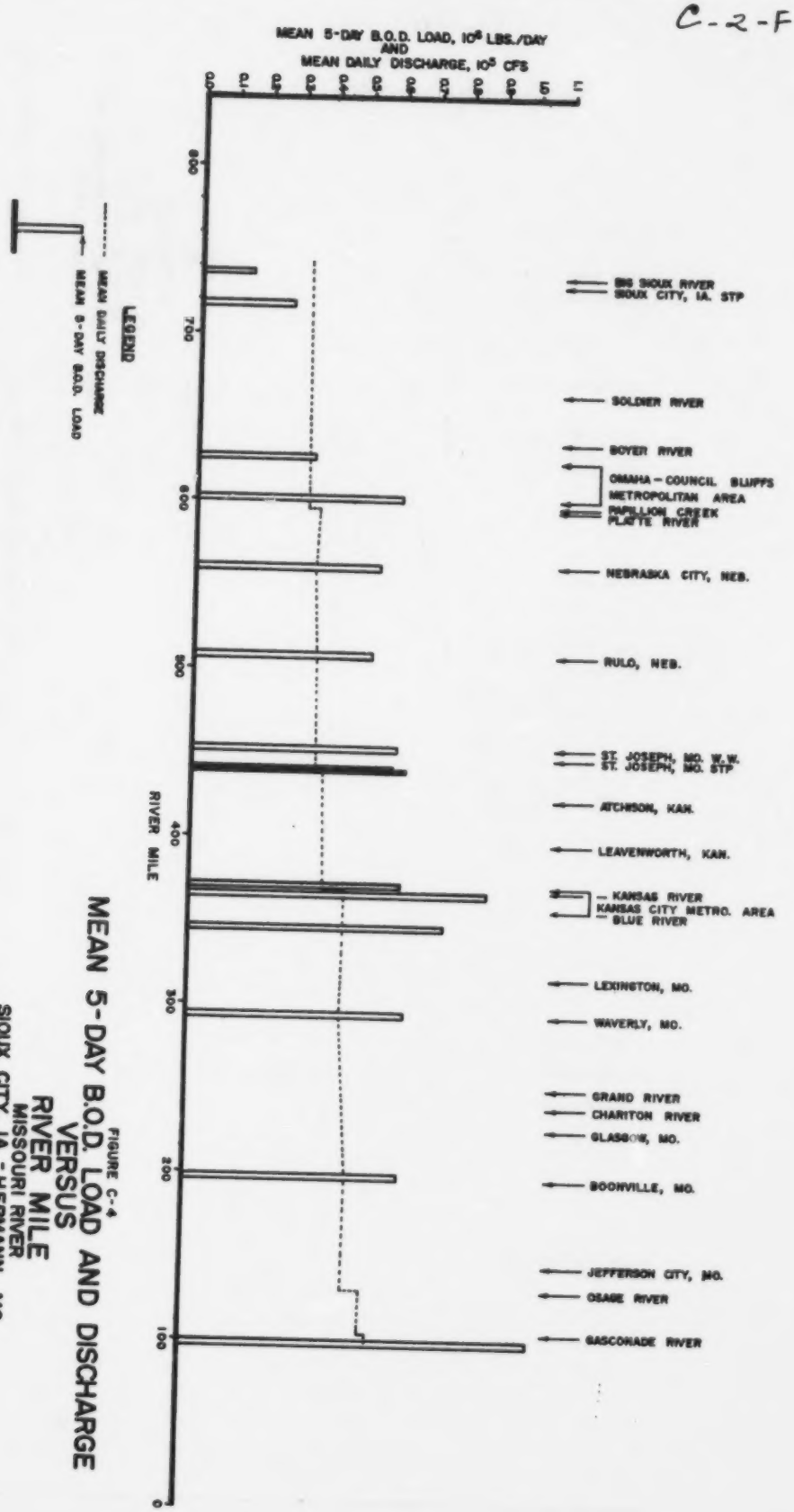


FIGURE C-4

MEAN 5-DAY B.O.D. LOAD AND DISCHARGE VERSUS RIVER MILE

MISSOURI RIVER
SIOUX CITY, IA. - HERMANN, MO.
OCT. - NOV., 1968

APPENDIX D

TIME-OF-WATER TRAVEL IN THE MISSOURI RIVER

The purpose of this analysis was to determine the time-of-water travel that occurred during the autumn of 1968 for the reach from Sioux City, Iowa to Hermann, Missouri. The time-of-water travel of solutes in the Missouri River has been computed for various flow rates in the reach from Yankton, South Dakota, to St. Louis, Missouri. The variations in the main stem flow that occur over this reach require that time-of-water travel be computed separately for several sub-reaches. The reference gage for each sub-reach is the one that measures inflow. For this analysis reference gages considered were the following:

Sioux City, Iowa; Omaha and Nebraska City, Nebraska; St. Joseph, Kansas City, Waverly, Boonville, Jefferson City, and Hermann, Missouri - the upstream gage being the reference gage for each reach.

The computed U. S. Geological Survey times-of-travel* were cumulatively summed for each station downstream, beginning with time equal 0 hours at the Sioux City gage. Flows used were 30,000, 40,000, and 50,000 cubic feet per second (cfs). The results were graphed (Figure D-1) versus the Missouri River mileage of the station. These three flow rates encompass the range of flows that occurred in the reach when studied in 1968.

For each sub-reach, the mean discharge (Table D-1) at the reference gage was calculated by linear interpolation and plotted between computed discharges. The flow line was constructed by connecting points within a sub-reach. An example of this procedure is presented for the sub-reach from Boonville to Jefferson City, Missouri. Mean discharge at the Boonville reference gage for the period of study from October 28, to November 8, 1968 was 48,500 cfs. Computed times-of water travel downstream from Sioux City, Iowa, in the sub-reach at bracketing flows were:

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* Bowie, J. E., and Petri, L. R., 1969, Travel of Solutes in the Lower Missouri River, U. S. Geological Survey Hydrol. Inv. Atlas BA-332.

a) Boonville:

174.9 Hours (40,000 cfs)

161.6 Hours (50,000 cfs)

b) Easely:

184.8 Hours (40,000 cfs)

171.1 Hours (50,000 cfs)

c) Jefferson City:

194.9 Hours (40,000 cfs)

180.3 Hours (50,000 cfs)

Interpolating for a flow equal to 48,500 cfs gave a time-of-water travel from Sioux City of: 163.6 hours at Boonville, 173.2 hours at Easely, and 182.5 hours at Jefferson City. Plotting these times versus the respective Missouri River mile and connecting with a straight line gave the flow line for the sub-reach. The cumulative travel times at the head and tail of each sub-reach were recorded so that the time-of-water travel could be adjusted for a change of flow in each adjacent sub-reach. In the Waverly to Boonville sub-reach, for instance, the time-of-water travel at the tail of the flow line at Boonville was 169.8 hours. This value will be needed to adjust the cumulative time-of-water travel downstream from Sioux City for variations in discharge.

To use the constructed flow lines for the various sub-reaches considered, the graph is entered from the abscissa at each respective station mileage for which the time-of-water travel is to be determined. Pivoting at the interpolated flow line and reading the ordinate gives a nominal time-of-water travel with respect to the Sioux City gage. This value must be corrected because the flow line from sub-reach to sub-reach is discontinuous due to changes in the discharge. In making this correction, use the two values of nominal time-of-water travel at the point of discontinuity - the reference gage. For example, the upstream sub-reach from Waverly to Boonville flow line had a nominal time of-water travel of 169.8 hours at Boonville. The adjacent downstream sub-reach from Boonville to Jefferson City had a nominal time-of-water travel of 163.6 hours. To make the time-of-water travel continuous, the 6.2 hours must be added to the downstream sub-reach. In this example the correction is additive because the downstream sub-reach discharge exceeded the upstream one. When the mean discharge at the downstream gage is less, the correction is negative. To determine the time-of-water travel from some initial

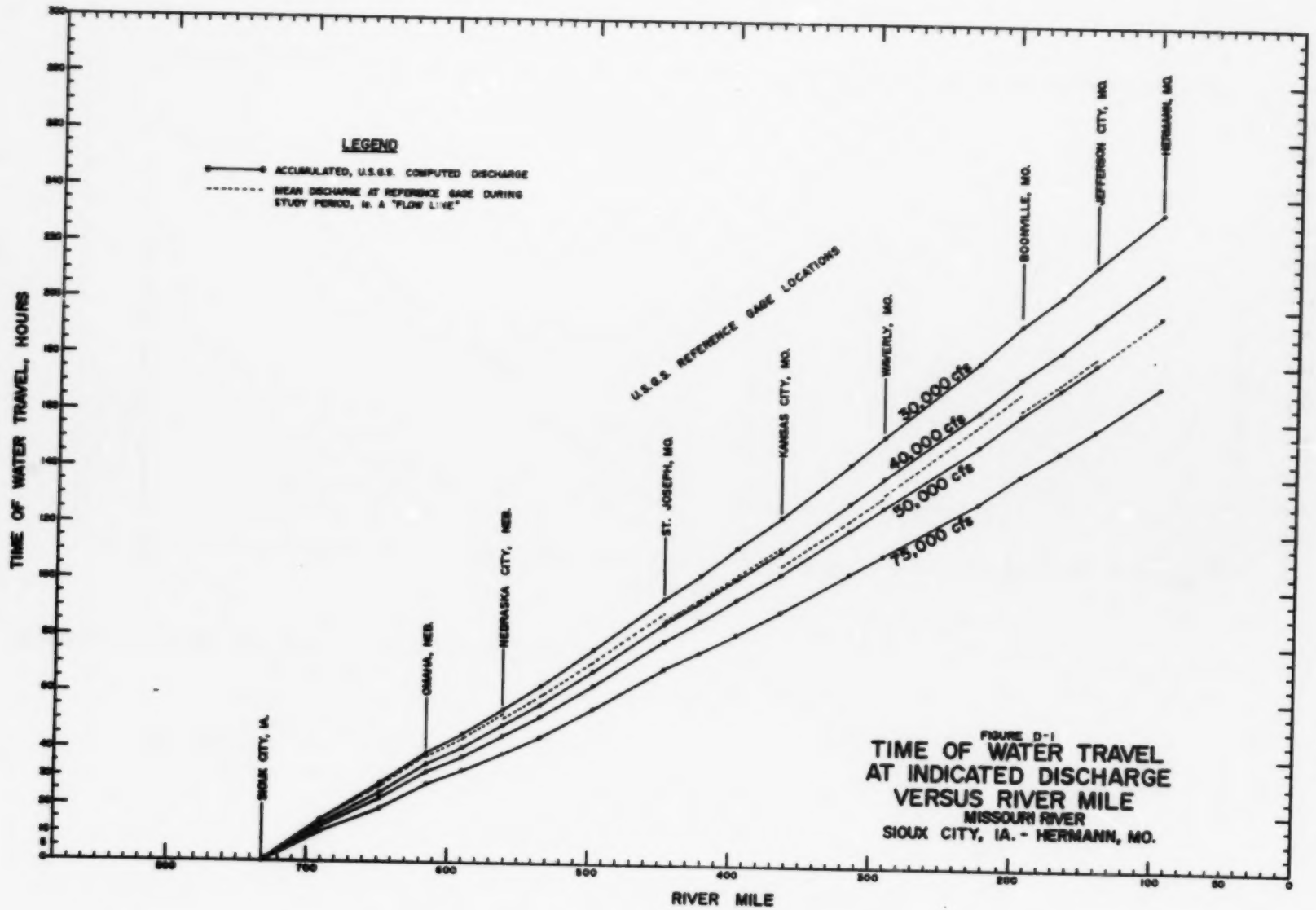

FIGURE D-1

TIME OF WATER TRAVEL AT INDICATED DISCHARGE VERSUS RIVER MILE

MISSOURI RIVER

SIOUX CITY, IA. - HERMANN, MO.

D-2-A

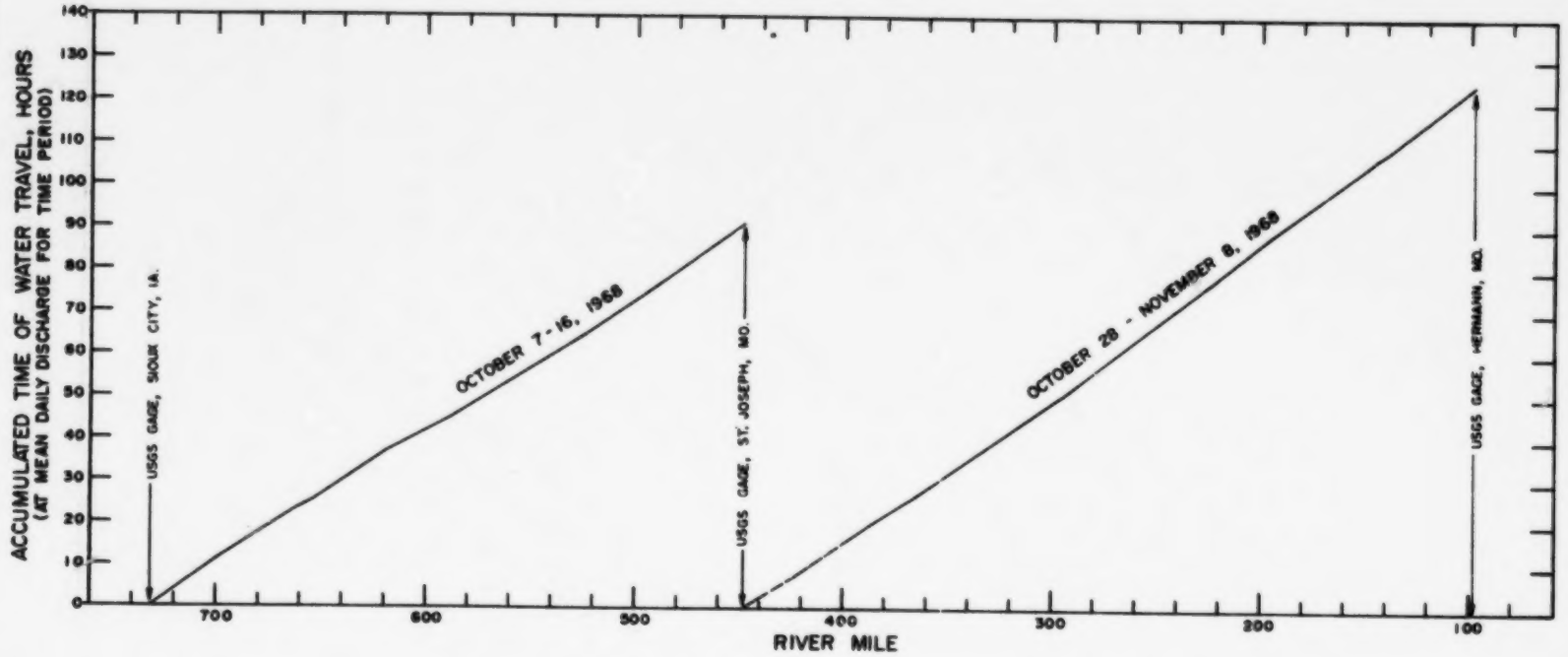

FIGURE D-2

ACCUMULATED TIME OF WATER TRAVEL
VERSUS
RIVER MILE
MISSOURI RIVER
SIOUX CITY, IA. - HERMANN, MO.
OCT. - NOV., 1968

D-2-B

TABLE NO. D-1

Time-of-Water Travel

MISSOURI RIVER
Fall, 1968 Navigation Season Surveys

Name	STATION River Mileage	Reference Gage	Nominal Trav. Time below Sioux City Hours	Correction account of Ref. GageChange Hours	Cumulative Correction Hours	Corrected Trav. Time below Sioux City Hours	Corrected Trav. Time below St. Joseph Hours
MISSOURI RIVER:							
M-52	736.0		-1.6[1]			-1.6[1]	
	731.8	Sioux City, Iowa	0.0			0.0	
M-50	730.0		0.5	0	0	0.5	
M-48	717.4		5.2	0	0	5.2	
M-47	699.5		11.3	0	0	11.3	
M-46	676.5		18.8	0	0	18.8	
M-44	654.6		25.2	0	0	25.2	
M-42	636.2		30.7	0	0	30.7	
M-41	618.3		37.3	0	0	37.3	
	615.8	Omaha, Nebraska					
M-39	610.5		39.0	+0.3	+0.3	39.3	
M-38	601.3		41.3	+0.3	+0.3	41.6	
M-36	591.2		43.9	+0.3	+0.3	44.2	
M-35	580.9		47.0	+0.3	+0.3	47.3	
	561.8	Nebraska City, Nebraska					
M-34	559.7		52.0	+1.5	+1.8	53.8	
M-33	546.7		55.9	+1.5	+1.8	57.7	
M-32	525.1		62.9	+1.5	+1.8	64.7	
M-31	507.5		68.8	+1.5	+1.8	70.6	
M-30	488.3		75.3	+1.5	+1.8	77.1	
M-29	469.0		82.1	+1.5	+1.8	83.9	
M-28	452.3		88.0	+1.5	+1.8	89.8	
	447.9	St. Joseph, Missouri	89.5	+1.5	+1.8	91.3	0.0
M-27	440.3		89.0	+2.8	+4.6	93.6	2.3
M-26	429.6		94.4	+2.8	+4.6	99.0	7.7
M-25.5	418.0		96.0	+2.8	+4.6	100.6	9.3
M-25	397.4		103.0	+2.8	+4.6	107.6	16.3
M-24	384.9		107.1	+2.8	+4.6	111.7	20.4
M-23	370.5		111.9	+2.8	+4.6	116.5	25.2
	363.7	Kansas City, Missouri					
M-21	365.6		106.9	+6.4	+11.0	117.9	26.6
M-20	359.3		109.1	+6.4	+11.0	120.1	28.8
M-18	345.4		113.8	+6.4	+11.0	124.8	33.5
M-17	334.5		117.6	+6.4	+11.0	128.6	37.3
M-16	313.2		125.0	+6.4	+11.0	136.0	44.7
M-15	293.4		131.9	+6.4	+11.0	142.9	51.6
	293.4	Waverly, Missouri					
M-14	270.0		141.4	-0.9	+10.1	151.5	60.2
M-12	241.2		152.3	-0.9	+10.1	162.4	71.1
M-10	235.1		154.7	-0.9	+10.1	164.8	73.5
M- 9	221.0		159.9	-0.9	+10.1	170.0	78.7
M- 8	197.2		169.3	-0.9	+10.1	179.4	88.1
	196.6	Boonville, Missouri					
M- 7	179.0		169.4	+6.2	+16.3	185.7	94.4
M- 6	169.0		175.4	+6.2	+16.3	191.7	100.4
	143.9	Jefferson City, Missouri					
M- 5	139.0		181.3	+8.2	+18.5	199.8	108.5
M- 3	118.0		189.2	+8.2	+18.5	207.7	116.4
M- 1	98.0		197.2	+8.2	+18.5	215.7	124.4

1/ Negative sign denotes upstream from reference gage.

TABLE NO. D-1
(contd)

Time-of-Water Travel

MISSOURI RIVER
NORMAL FALL - Oct. 7-16, and Oct. 28-Nov. 8, 1968
TRIBUTARIES, MUNICIPALITIES AND WASTE SOURCES

STATION Name	River Mileage	Reference Gage	Nominal Trav. Time below Sioux City Hours	Correction account of Ref. GageChange Hours	Cumulative Correction Hours	Corrected Trav. Time below Sioux City 2/ Hours	Corrected Trav. Time below St. Joseph 3/ Hours
Big Sioux River	734.0		-0.8	0	0	-0.8 1/	
	731.8	Sioux City, Iowa	0.0	0	0	0.0	
Sioux City	729.0		+0.7	0	0	+0.7	
Soldier River	664.0		22.5	0	0	22.5	
Boyer River	635.1		31.6	0	0	31.6	
Omaha-Council Bluffs - Metro. Area Upper Boundary	624.0		35.4	0	0	35.4	
	615.8	Omaha, Nebraska					
Council Bluffs	614.0		38.1	+0.3	+0.3	38.4	
So. Omaha - Monroe St. Severs	611.5		38.8	+0.3	+0.3	39.1	
Omaha-Council Bluffs Metro. Area - Lower Boundary	601.0		41.3	+0.3	+0.3	41.6	
Papillion Creek	596.6		42.7	+0.3	+0.3	43.0	
Platte River	594.8		43.0	+0.3	+0.3	43.3	
Nebraska City	562.0		53.0	+0.3	+0.3	53.3	
	561.8	Nebraska City, Nebraska					
St. Joseph Water Co. Intake	452.3		88.0	+1.5	+1.8	89.8	
	447.9	St. Joseph, Mo.				91.3	0.0
St. Joseph	447.0		87.0	+2.8	+4.6	91.6	0.3
Atchison	422.5		94.4	+2.8	+4.6	99.0	7.7
Leavenworth	396.0		103.3	+2.8	+4.6	107.9	16.6
Kansas City, Kansas - Mo. Metro. Area - Upper Boundary	369.0		112.3	+2.8	+4.6	116.9	25.6
Kansas River	367.4		112.9	+2.8	+4.6	117.5	26.2
Kansas City, Kans.	367.2		113.0	+2.8	+4.6	117.6	26.3
	365.7	Kansas City, Mo.					
Blue River - Kansas City Metro. Area - Lower Boundary	356.9		109.9	+6.4	+11.0	120.9	29.6
Lexington	316		124.0	+6.4	+11.0	135.0	43.7
	293.4	Waverly, Mo.					
Grand River	250.0		149.0	-0.9	+10.1	159.1	67.8
Chariton River	238.8		153.1	-0.9	+10.1	163.2	71.9
Glasgow	226.0		158.0	-0.9	+10.1	168.1	76.8
Boonville	196.6		169.8	-0.9	+10.1	179.9	88.6
	196.6	Boonville, Mo.					
Jefferson City	145.0		181.9	+6.2	+16.3	198.2	106.9
Osage River	130.0		184.9	+2.2	+18.5	203.4	112.1
Gasconade River	104.4		194.3	+2.2	+18.5	212.8	121.5

1/ Negative sign denotes upstream from reference gage.
2/ October 7-16 study period pertains to reach from Sioux City to St. Joseph - River Mile 447.9.
3/ October 28-November 8, 1968 study period pertains to reach from St. Joseph to Hermann, Missouri - River Mile 98.0.

point on the Missouri River, the above procedure must begin at that point and proceed downstream. The corrections for discontinuity in flow are cumulative from sub-reach to sub-reach in downstream order.

The corrected time-of-water travel downstream from Sioux City to St. Joseph is a mean for the study period from October 7-16, 1968; from St. Joseph to Hermann, is for the period from October 28 - November 8, 1968. In addition to the discontinuities mentioned, one further break in the data is caused by the change in study periods at St. Joseph. Flow at the St. Joseph gage in the October 7-16, 1968 survey period averaged 36,600 cfs, in the October 28 - November 8 survey period the flow averaged 38,800 cfs.

Table D-1 presents the nominal and corrected travel times and the correction factors used in this analysis. Figure D-2 shows the time-of-water travel downstream from Sioux City, Iowa, and St. Joseph, Missouri, for the respective periods of study.

As a precaution before using these data, the qualifications cited in the basic data reference should be examined:*

> "The data in this report are for a full conservative soluble contaminant. Contaminants that do not fall into this category such as, low-density oily wastes, might move at rates considerably different from those of a conservative soluble contaminant.
>
> "A contaminant may be introduced into the river in many ways. It might be introduced suddenly or gradually, or it might be introduced along the bank or near midstream. The mode of introduction can affect significantly both the travel time and the maximum concentrations attained."

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*Ibid.